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FINAL REPORT

THE MITES ASSOCIATED WITH *IPS TYPOGRAPHUS*--A SEARCH FOR EXOTIC MITE PREDATORS OF THE SOUTHERN PINE BEETLE

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FINAL REPORT

THE MITES ASSOCIATED WITH *IPS TYPOGRAPHUS*--A SEARCH FOR EXOTIC MITE PREDATORS OF THE SOUTHERN PINE BEETLE

by

John C. Moser and Hermann Bogenschutz

The attached manuscript, "A key to the mites associated with flying *Ips typographus* in South Germany," serves as the final report for this study. The manuscript will be submitted for publication to a journal in Europe.

This study is closed.

INTRODUCTION

In recent years, there has been a concerted effort in Europe to reduce populations of the spruce bark beetle, *Ips typographus* (L. 1758), by utilizing large numbers of traps baited with synthetic pheromones (Bakke 1981, Vite 1980, and Zumr 1982). There has also been a growing interest in developing ways in which the beetle's natural enemies, including its associated mites can be used for control (Kielczewski 1976, Lieutier 1978). In addition, there has been one attempt to utilize *Pyemotes dryas* (Vitzthum 1923), a mite parasite of European spruce bark beetles, for the biological control of the southern pine beetle, *Dendroctonus frontalis* Zimmermann 1868, in the United States (Moser et al. 1978).

The number of mite species associated with *I. typographus* is unknown, although Kielczewski 1976 listed 23 species associated with a large number of bark beetles in Poland. The current *I. typographus* trapping program in Europe affords an excellent opportunity to compile a more accurate list of its phoretic mites. The large number of beetles collected permits the systematic sampling of the phoretic mites. In addition, it offers an inexpensive and efficient method of collecting live mites for biological studies, including potential candidates for the biological control of exotics, such as the southern pine beetle.

The first step in the search for the mite natural enemies of any bark beetle, including Ips typographus, is to compile a list of all of the associated mite species with keys to their identification. Until this is done, workers unfamiliar with mite taxonomy find it difficult to identify specimens, and face an almost impossible task of selecting the most appropriate natural enemies on which to concentrate their efforts.

To alleviate this problem for I. typographus, we constructed the following key to the phoretic mites in South Germany, together with some of the biological characteristics of the mites.

METHODS

Flying I. typographus were trapped during the May-September seasons in 1980 and 1981. Traps were placed at various localities in the southern part of the State of Baden-Wurttemberg, Federal Republic of Germany, mostly in the vicinity of the Black Forest.

Traps were of three basic designs (tubes, cones, and window traps), all of which were baited with Pheroprax^{R},[2] a pheromone-impregnated plastic wafer sealed inside a small polyethylene bag. Collected weekly from traps, beetles were placed in alcohol vials and sent to the Forest Insect Project, Southern Forest Experiment Station, Pineville, LA, USA. Eight thousand seventy beetles were sent in 12 vials of alcohol in 1980 and 4284 were sent in 10 vials in 1981. A sample of one hundred beetles were taken from each vial except for the last two vials in 1981 which contained only 37 and 13 beetles, respectively. The species and numbers of mites found on each beetle were tallied and their location noted: under elytra, on elytra, elytral declivity, ventral abdomen, dorsal thorax, ventral thorax, coxae, legs, and head.

In addition, the sediments at the bottoms of the vials were searched for any mites that may have fallen off the beetles. The phoretic mites and those from the sediments were tallied separately.

RESULTS

A total of 2050 adult beetles were examined for phoretic mites. Of the 1200 sampled in 1980, 35.6% possessed mites; of the 850 in 1981, 30.0% had mites. The average number of phoretic mites per beetle was 1.10 for all beetles, but 3.30 for those beetles with mites. This is a conservative figure, since many mites fell off the beetles after they were placed in the alcohol. The percent of beetles with mites varied from 9 to 60 percent in the 22 samples. In samples with low percentages most beetles were partially deteriorated before being placed in alcohol; presumably this contributed to the loss of phoretic mites.

Fifteen mite species were found on the beetles (and thus judged phoretic) (Table 1). Although we believe that most of these mites were truly phoretic, a few may have been accidentally stuck to the beetles.

The total number of phoretic mites extracted from the 2050 adult beetles was 2249; 61.5% (mostly Dendrolaelaps quadrisetus) were under the elytra, 24.2% ventral thorax, 10.6% ventral abdomen, 2.9% coxae, and less than 1% for the other body locations.

Those mites found in the alcohol sediments were mostly the same species as those found attached to the beetles. Species that we think may have accidently fallen or crawled into the traps were culled from Table 2. All the sediment samples included 15 phoretic species (Table 1) that comprised 92% of the total 1667 mites tallied (Table 2).

Those rarer phoretic species (Table 1) were without exception much more common as percentages of the alcohol sediments (Table 2), indicating that these species were easily dislodged. The percent adjustment in Table 1 is the average percent of the attached and detached specimens. We think that this combined average more realistically reflects the original percentages of phoretic mite species before the beetles were placed in alcohol.

The 17 species that were present in the alcohol but were not among those attached to the beetles were all uncommon or rare, representing only 7.9% of the total specimens in the sediments. They are included in our key because they are species that could have occurred phoretically in low numbers and might have been easily dislodged from _I. typographus_. They could also have been transported by other Coleoptera such as _Geotrupes stercorosus_ Fcriba 1891, a scarabaeid not associated with the habitat of _I. typographus_, or _Thanasimus formicarius_ L. 1758, a clerid predator of _I. typographus_ that were trapped in low numbers.

Many of the 7.9% may eventually be documented as phoretic on _I. typographus_, and indeed at least one species already has been. Gaebler (1947) recorded _Iponemus gaebleri_ as phoretic on _I. typographus_. Another, the oribatid _Paraleius leontonychus_ is apparently non-selective with regard to its phoretic bark beetle host, having been found on bark beetles of three different genera (Norton 1980). Kielczewski (1976) and Lieutier (1978) also record this species from galleries of _I. typographus_. _Pyemotes dryas_, although represented by only one specimen in the sediments, appears to be commonly phoretic on other spruce bark beetles such as _Polygraphus poligraphus_ (L. 1758), although its exact relationship to _I. typographus_

is uncertain. But phoretic abundance sometimes bears little relationship to the commonness of a mite species in the galleries of a bark beetle. *Histiogaster arborsignis*, for example, may be common in galleries of *Dendroctonus frontalis* (Moser and Roton 1971), although it is rare-infrequent on bodies of flying adults.

The biologies of most of the 32 species are unknown, but three are undoubtedly parasites on various stages of beetle brood. *Iponemus gaebleri* preys on eggs of *Ips* spp. including *I. typographus* (Gaebler 1947); *Pyemotes dryas* preys on brood of spruce bark beetles (Moser et al. 1978). Although the biology of *Paracarophaenax ipidarius* is unknown, related species feed on beetle eggs (Rack 1959). *Paracarophaenax ipidarius* was not only the most common of the three species, but definitely phoretic on *I. typographus*. Of the three, it may account for the most brood mortality.

The thirty-two mite species listed in Table 2 are all included in the following key to mite species possibly phoretic on flying *I. typographus*. The total number of species associated with the subcortical habitat may be much higher. Those species actually found on the beetle adults are starred. Moser and Roton (1971) listed 96 species of mites within the subcortical habitat of *D. frontalis*, but only 15 species were included by Kinn (1976) in a key to the phoretic species.

It is important to note that the figures accompanying the key emphasize morphological characters to separate the various species in the key. They are not intended for discriminating between closely related species.

KEY TO MITES ASSOCIATED WITH FLYING *IPS TYPOGRAPHUS*

1. Chelicerae large and easy to see; chelae toothed for grasping or grinding (fig. 6) 2

1'. Chelicerae absent or small and difficult to see; when present chelae usually stylet-like modified for piercing (fig. 14, 29) 13

2. Mites more or less flattened with peritremes located on lateral region of the body; pseudostigmatic organs absent (fig. 5)... Cohort gamasina 3

2'. Beetle-like mites; usually heavily sclerotized; most cannot be mounted on slides without crushing. Peritremes absent. Pair of pseudostigmatic organs present (fig. 12)...Superorder Oribatida (adults) 9

3. Turtle shaped; legs can be withdrawn into groves; attached to beetle by anal pedicle (fig. 1)...Family Uropodidae (deutonymphs) 4

3'. Not turtle shaped; leg grooves absent; attached to beetle by the mouthparts and/or leg claws...Cohort gamasina 6

4. Setae on dorsal shield thick and long; more than one-half as long as distance between setal bases (fig. 1) ....*Trichouropoda polytricha**

4'. Setae on dorsal shield thin and short, less than one-half as long as distance between setal bases (fig. 2) 5

5. Numerous light refractant spots on sternal shield (fig. 2) ....*Uroobovella vinicolora**

5'. Without numerous light refractant spots on sternal shield (fig. 3) ....*Uroobovella ipidis**

6. Distinct line above legs III and IV dividing the dorsal shield into two plates (fig. 5) (deutonymphs) 7

6'. Dorsal shield not divided (fig. 4) Family Ascidae (females) ....*Proctolaelaps fiseri**

7. One or two pairs of setae at posterior end of dorsal shield at least five times longer than adjacent setae, and at least one-third as long as leg four (fig. 6) Family Digamasellidae 8

7'. None of the posterior setae of the dorsal shield more than twice as long as smallest adjacent setae, and none more than one-fifth as long as leg IV (fig. 5) Family Parasitidae ....*Vulgarogamasus* n.sp. #3

8. One pair of long posterior dorsal setae (fig. 6) ....*Dendrolaelaps disetus*

8'. Two pairs of long posterior setae (fig. 7) .... *Dendrolaelaps quadrisetus**

9(2'). Single large claw on legs (fig. 8) 10

9'. Three claws on legs (fig. 10) 11

10. Claw strongly curved backward (fig. 8) Family Oribatulidae .. .. Paraleius leontonychus

10'. Claw evenly curved (fig. 9) Family Carabodidae ....Carabodes labyrinthicus

11. Genital and anal plates almost adjacent to each other (fig. 10) Family Cymbaeremaeidae .... Cymbaeremaeus cymba

11'. Genital and anal plates separated by at least the length of the genital plate (fig. 11) 12

12. Small, weakly sclerotized, and more or less flattened mite, capable of being mounted on a slide; setae on dorsal shield long, setal tips capable of touching if pointed toward each other (fig. 11) Family Oribatulidae ....Eporibatula gessneri

12'. Large, strongly sclerotized, rounded mite; setae on dorsal shield short, setal tips not capable of touching (fig. 12) Family Liacaridae ....Adoristes ovatus

13(1'). Mouthparts greatly reduced and nonfunctional; opisthosomal sucker plate present (fig. 13)...Order Acariformes--Supercohort Acaridides (hypopae=deutonymphs) 14

13'. Mouthparts present, opisthosomal sucker plate absent (fig. 24). Order Acariformes--Subcohort Heterostigmae (females) 24

14. All legs stout, although in some families leg IV may appear slender because of two thick tarsal setae which are longer than the leg; legs III and IV often directed backward (fig. 13) .. 15

14'. Legs I and II stouter than legs III and IV; legs III and IV often directed forward and have long, slender distal segments (fig. 20) Family Histiostomatidae (=Anoetidae)........................ 21

15. Leg IV without claws; terminating with two thick setae which are longer than the leg (fig. 13) Superfamily Hemisarcoptoidea .. 16

15'. Leg IV terminating with a claw (fig. 14) Superfamily Acaroidea 17

16. Solenidia on head short and poorly developed; Tarsus III very short, bearing only 3 setae (fig. 13)...Family Hemisarcoptidae ....Nanacarus n. sp. #13

16'. Solenidia on head long and well developed; Tarsus III longer, with more than 3 setae (fig. 14)...Family Winterschmidtiidae (=Saproglyphidae) ....Calvolia n. sp. #33*

17. Median epimere absent, and epimere III open at apical end (fig. 15) 18

17'. Median epimere present and epimere III closed at apical end (fig. 17) 19

18. Eyes closely spaced at anterior edge of dorsum (fig. 15) ....<u>Histiogaster</u> <u>arborsignis</u> *

18'. Eyes widely separated, some distance posterior to edge of dorsum (fig. 16) ....<u>Thyreophagous</u> <u>corticalis</u> *

19. Leg IV terminal setae stout, at least twice as long as leg IV (fig. 17) ....New Genus, n. sp. #27

19'. Leg IV terminal setae thin, not more than twice as long as leg IV (fig. 18) 20

20. Posterior epimeres II joined at base by a <u>very</u> thin sclerite; median apodeme connecting epimers III and IV undivided; gnathosomal remnant always undivided (fig. 18) <u>Schwiebea</u> n.sp.#10*

20'. Posterior epimeres II never joined at base; median apodeme connecting epimeres III and IV partially divided; gnatosomal remnant usually divided (fig. 19) ....<u>Schwiebea</u> n. sp.#31

21(14'). Anterior opisthosomal setae elongate, overlapping bases of adjacent setae (fig. 21) 22

21'. Anterior opisthosomal setae shorter, not overlapping bases of adjacent setae (fig. 23) 23

22. Anterior opisthosomal setae long, thick (fig. 20) ....<u>Histiostoma</u> <u>piceae</u> *

22'. Anterior opisthosomal setae shorter, thin (fig. 21) ....<u>Histiostoma</u> <u>serrata</u> *

23. Seta dp4 more than one-half as long as distance to base of dp3 (fig. 22) ....<u>Histiostoma</u> <u>dryocoeti</u>

23'. Seta dp4 not more than one-quarter as long as distance to base of dp3, (fig. 23) ....<u>Histiostoma</u> n. sp. #23

24(13'). Leg IV without claws and terminating with two whiplike hairs (fig. 24) 25

24'. Leg IV terminating with two claws (fig. 28)...Family Pyemotidae 28

25. Leg I terminating with single large claw specialized for grasping beetle setae (fig. 24)...Family Scutacaridae..<u>Scutacarus</u> <u>scolyti</u> *

25'. Leg I terminating with small claws (fig. 25)...Family Tarsonemidae 27

26. Dorsal setae conspicuously stout; dorsal surface conspicuously punctate or striate (fig. 25) ....Iponemus gaebleri *

26'. Dorsal setae thin; dorsal surface smooth (fig. 26) Tarsonemus . 27

27. Apodemes III extending laterally beyond bases of legs III (fig. 26) ....Tarsonemus subcorticalis *

27'. Apodemes III not extending laterally beyond bases of legs III (fig. 27) ....Tarsonemus ips

28. Mouthparts adapted for piercing-sucking; pharyngeal pump and/or stylets enlarged (fig. 28) 29

28'. Pharyngeal pump and stylets small, difficult to see (fig. 30).. 30

29. Body slender, dorsum ridged (fig. 28) ....Pyemotes dryas

29'. Body stocky, dorsum smooth (fig. 29)...Paracarophaenax ipidarius *

30. Median apodeme and apodemes III and IV well developed, easy to see (fig. 32) 31

30'. Median apodeme poorly developed and apodemes III and IV very poorly developed or absent (fig. 30) ....Pygmephorellus sp(p)

31. Dorsal setae thick; body heavily sclerotized (fig. 31) ....Pseudopygmephorus bogenschutzi

31'. Dorsal setae of normal thickness; body normally sclerotized (fig. 32) ....Bakerdania hylophila

Table 1.--Mite species phoretic on adult *Ips typographus*.

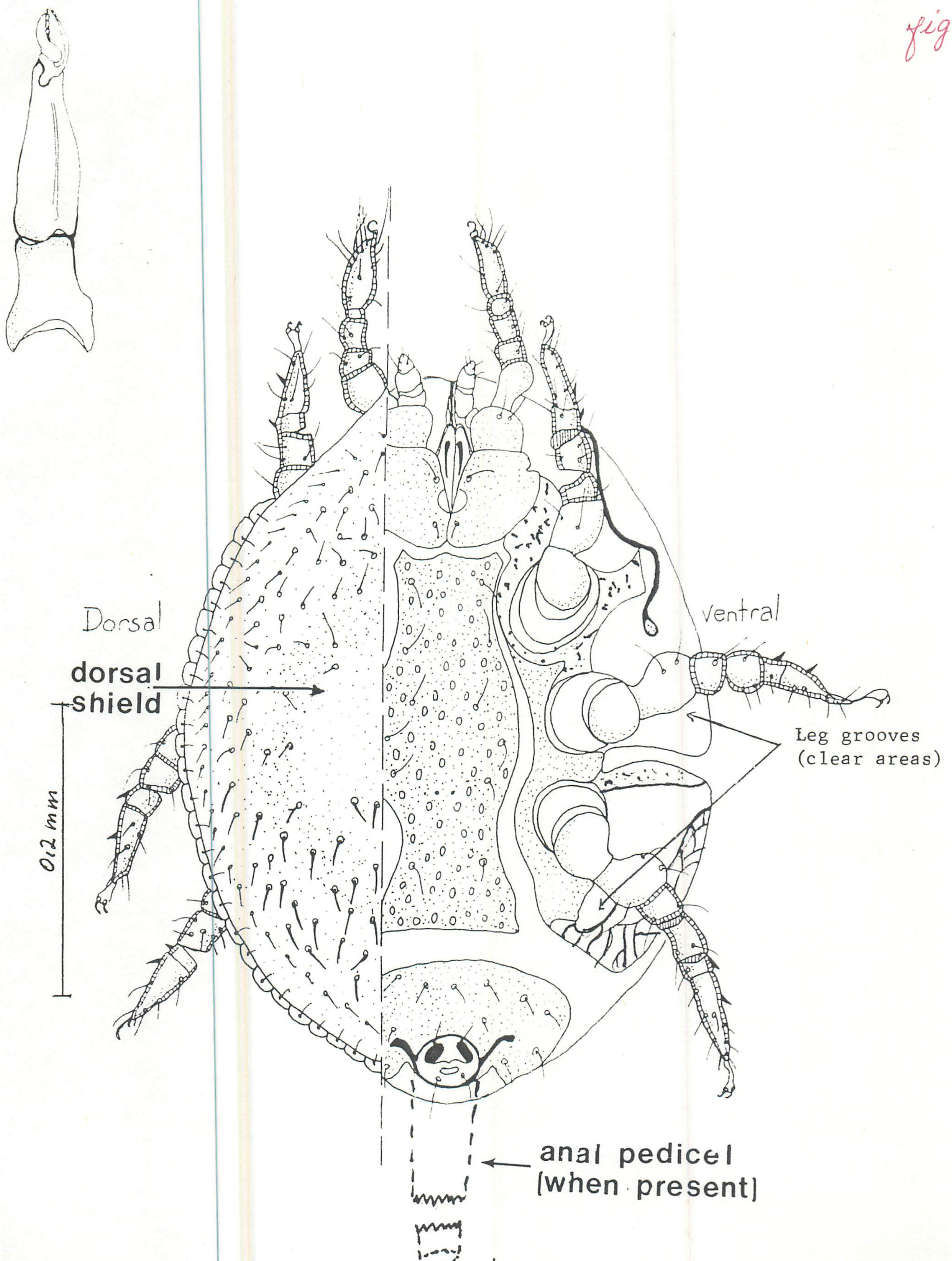
Species	Body location	No. of Mites	% of Grand total	Average % Adjustment[1]
Trichouropoda polytricha	Elytral declivity	156		
	Ventral abdomen	3		
	Ventral thorax	40		
	Coxae	4		
	Head	2	9.1	9.8
Uroobovella vinicolora	Under elytra	1		
	Elytral declivity	2		
	Coxae	1	0.02	0.3
Uroobovella ipidis	Elytral declivity	76		
	Ventral abdomen	1		
	Dorsal thorax	2		
	Ventral thorax	473		
	Coxae	61		
	Legs	1		
	Head	3	27.4	21.0
Proctolaelaps fiseri	Under elytra	1		
	Elytral declivity	2	0.01	0.5
Dendrolaelaps quadrisetus	Under elytra	1317		
	Ventral thorax	1	58.6	32.6
Calvolia sp. #33	Ventral abdomen	1	<0.01	0.1
Histiogaster arborsignis	On elytra	1	<0.01	0.1
Thyreophagus corticalis	Under elytra	1	<0.01	0.2
Schwiebea sp. #10	Under elytra	1	<0.01	0.5
Histiostoma piceae	Under elytra	56		
	On elytra	1		
	Elytral declivity	2		
	Ventral abdomen	1		
	Ventral thorax	3		
	Head	1	2.9	22.1
Histiostoma serrata	Under elytra	1	<0.01	0.1
Scutacarus scolyti	Ventral thorax	13	0.01	3.0
Iponemus gaebleri	Under elytra	2		
	Elytral declivity	1	0.01	0.2
Tarsonemus subcorticalis	Under elytra	3		
	Dorsal thorax	1	0.02	2.6
Paracarophaenax ipidarius	Ventral thorax	13	0.6	1.3
Grand total		2249	99.2%	94.0%

[1]Average of attached (Table 1) and detached (Table 2) percentages.

ACKNOWLEDGMENTS

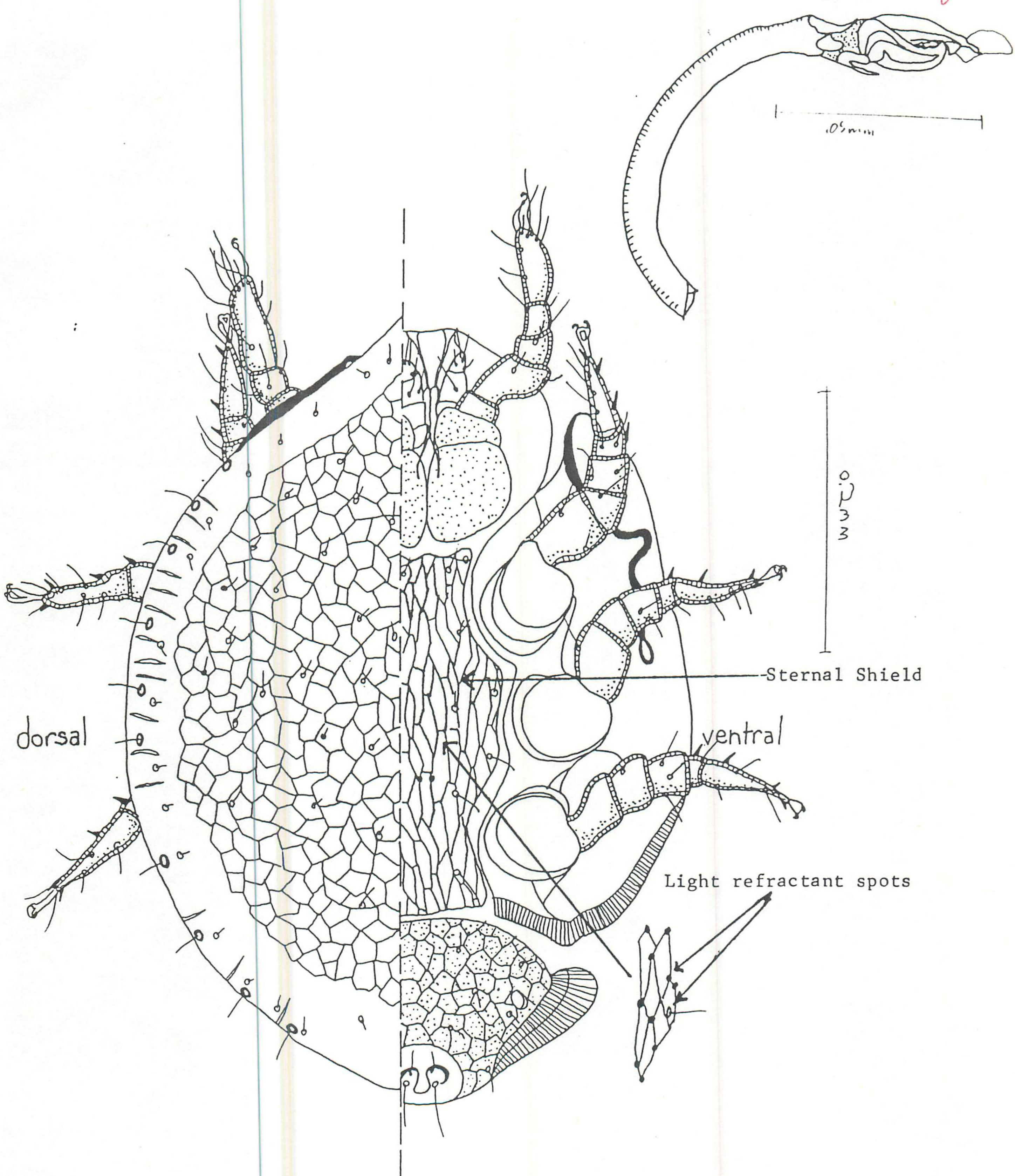
This paper would not have been possible without the cooperation of the following specialists who provided identifications and/or described the many new species discovered during the course of the study. Taxonomic specialties follow names. E. A. Cross (Pyemotidae), W. Hirschmann (Uropodidae,Digamasellidae), E. E. Lindquist (Ascidae,Tarsonemidae), S. Mahunka (Scutacaridae,Pyemotidae), W. Niedbala (Oribatidae), R. A. Norton (Oribatidae), B. M. O'Connor (Astigmata), R. L. Smiley (Pyemotidae). We also thank the following who reviewed the manuscript: B. M. O'Connor, A. Bakke, H. Eidmann, H. Bodvarsson, and B. Ehnstrom.

fig. 1



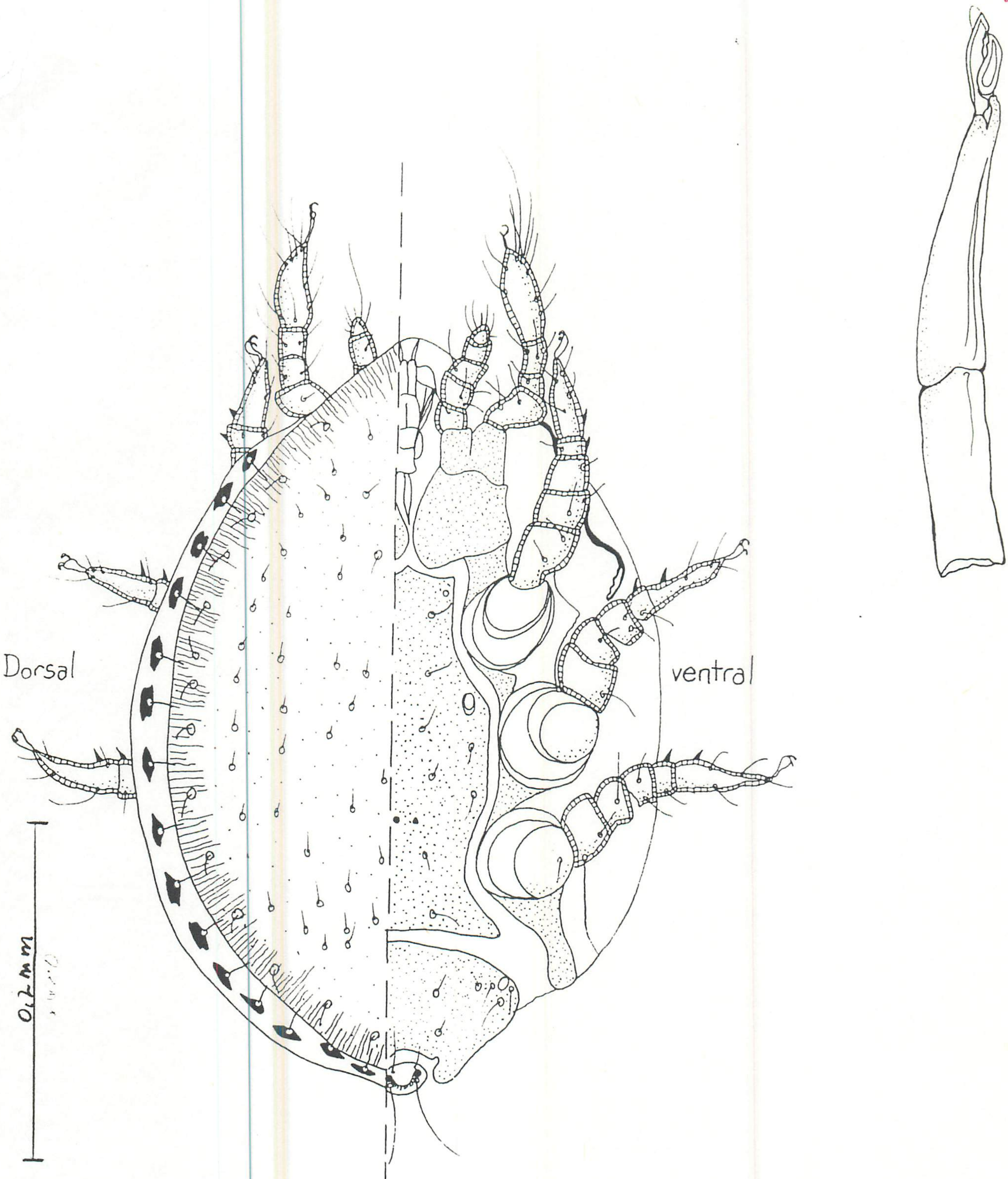
Tricho uropoda polytricha

fig. 2



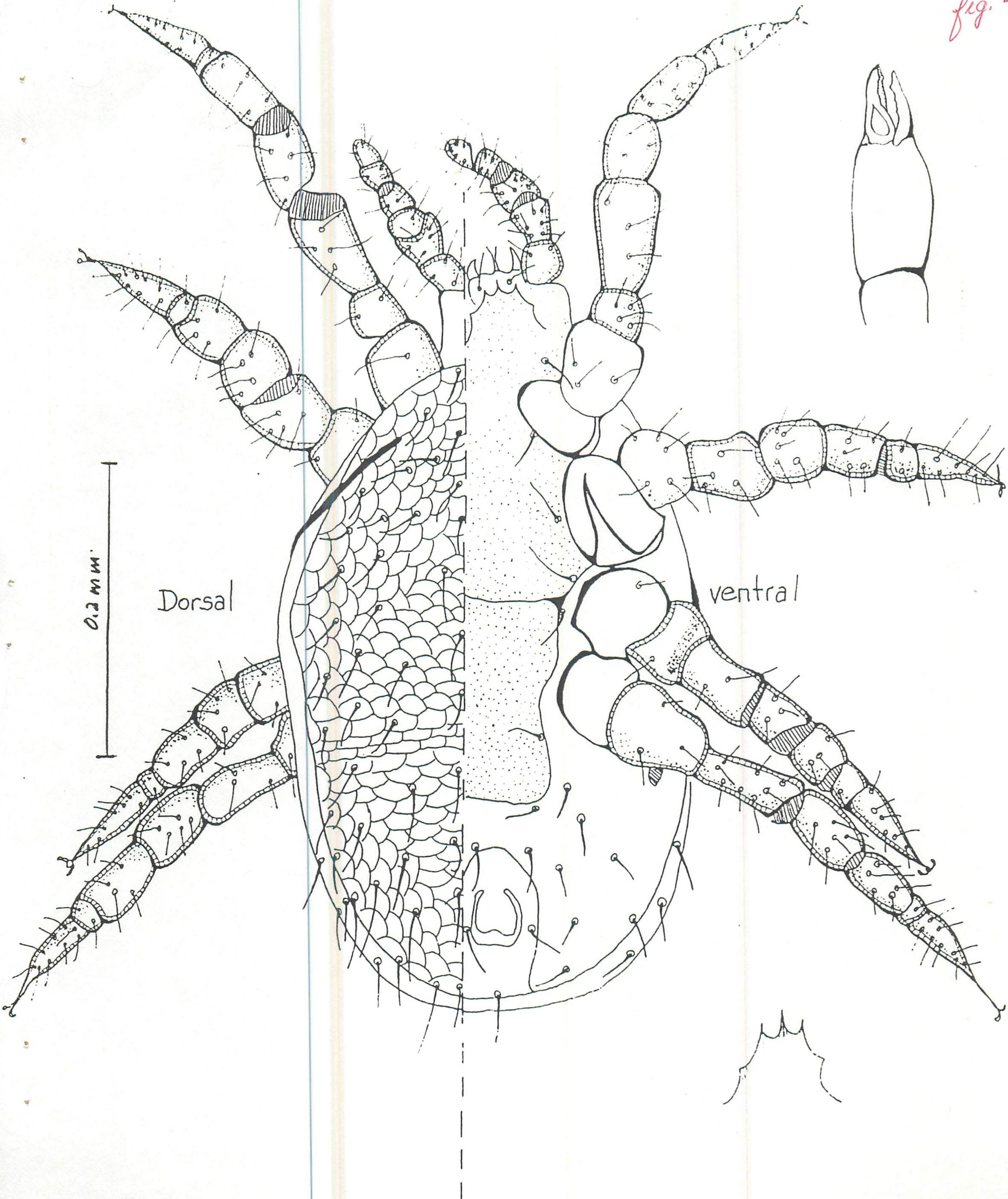
Uroobovella vinicolora

fig. 3



Uroobovella ipidis

fig. 4



Proctolaelaps fiseri

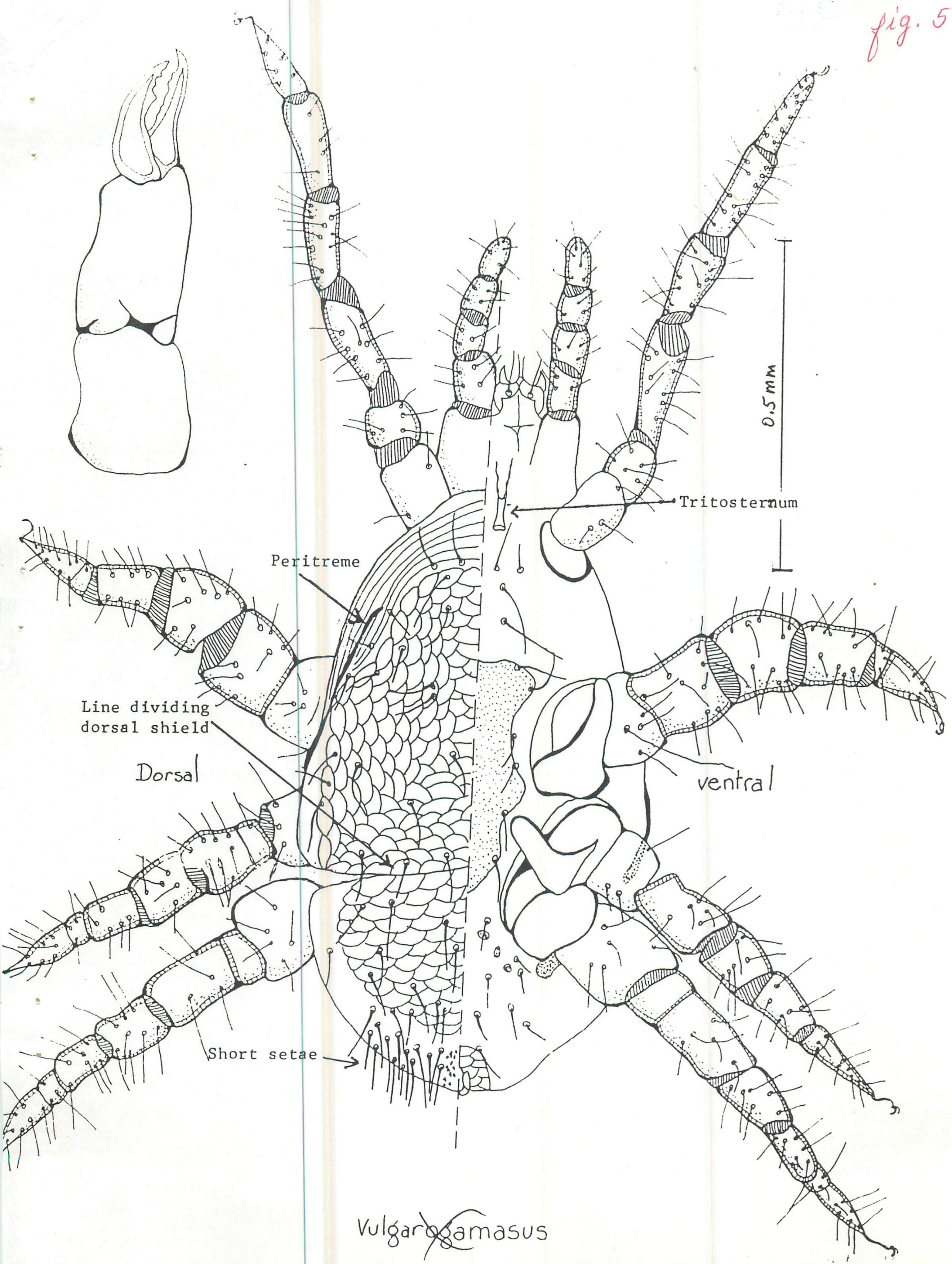
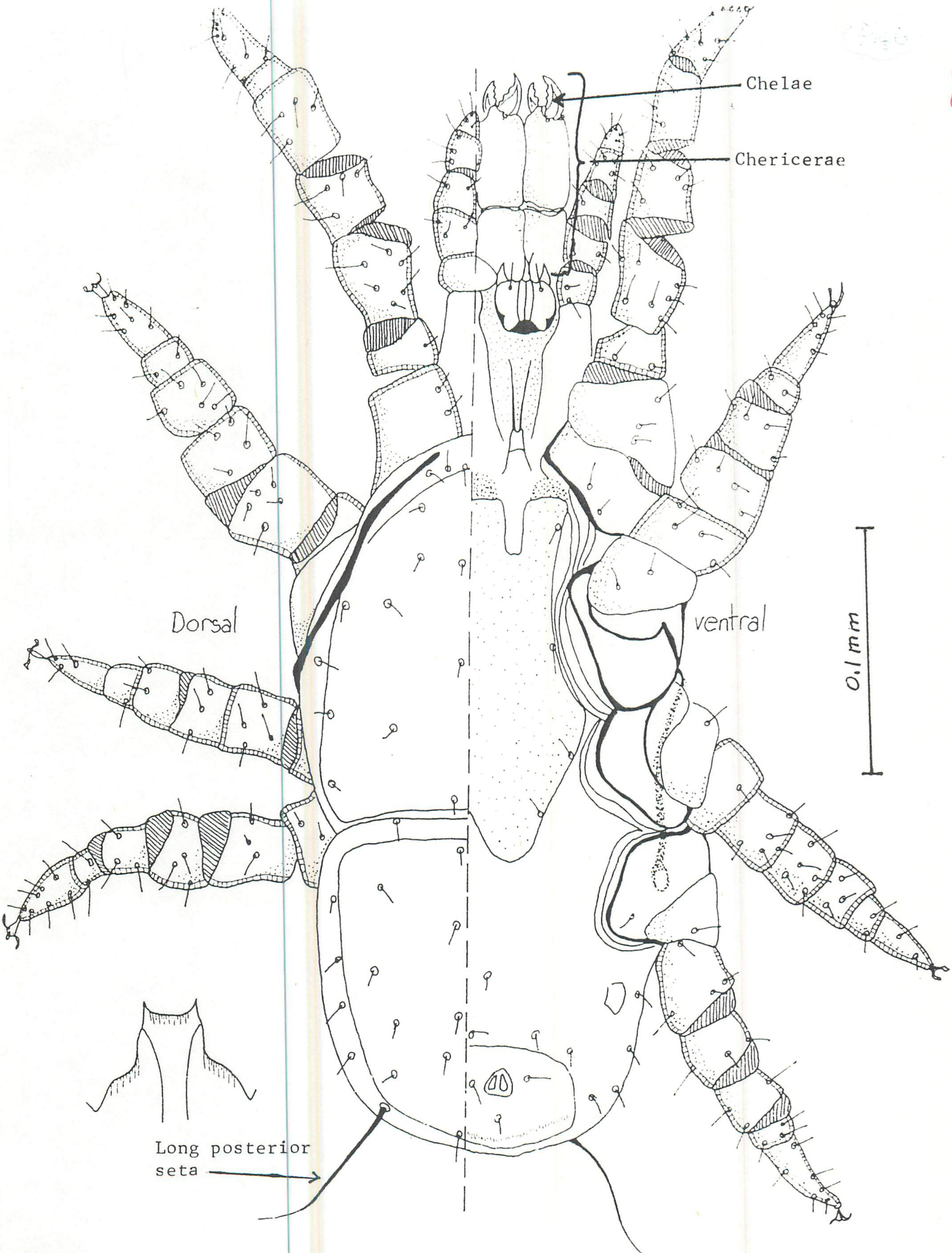


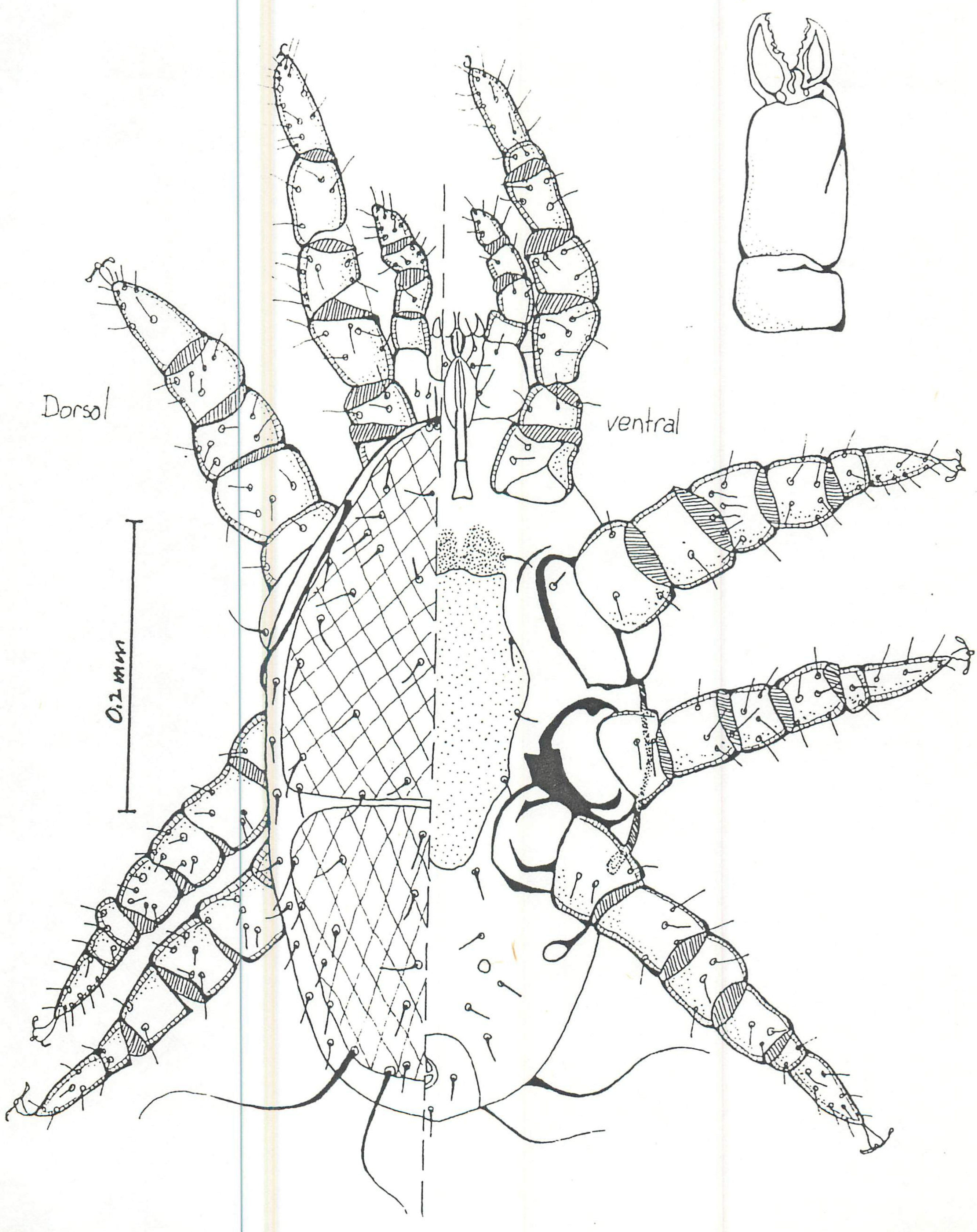
fig. 5
0.5 mm
Tritosternum
Peritreme
Line dividing dorsal shield
Dorsal
ventral
Short setae
Vulgarogamasus

fig. 6



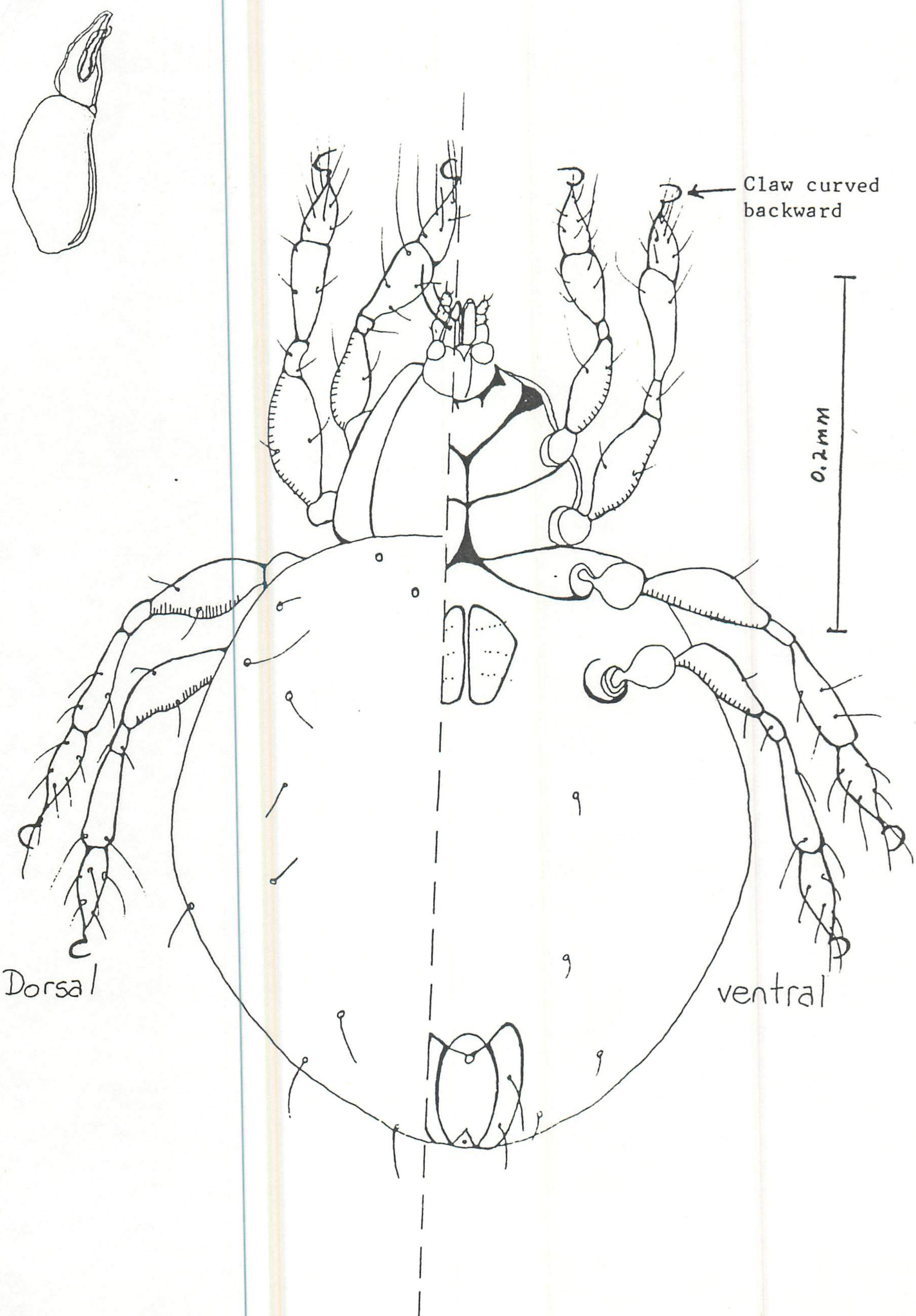
Dendrolaelaps disetus

fig. 7



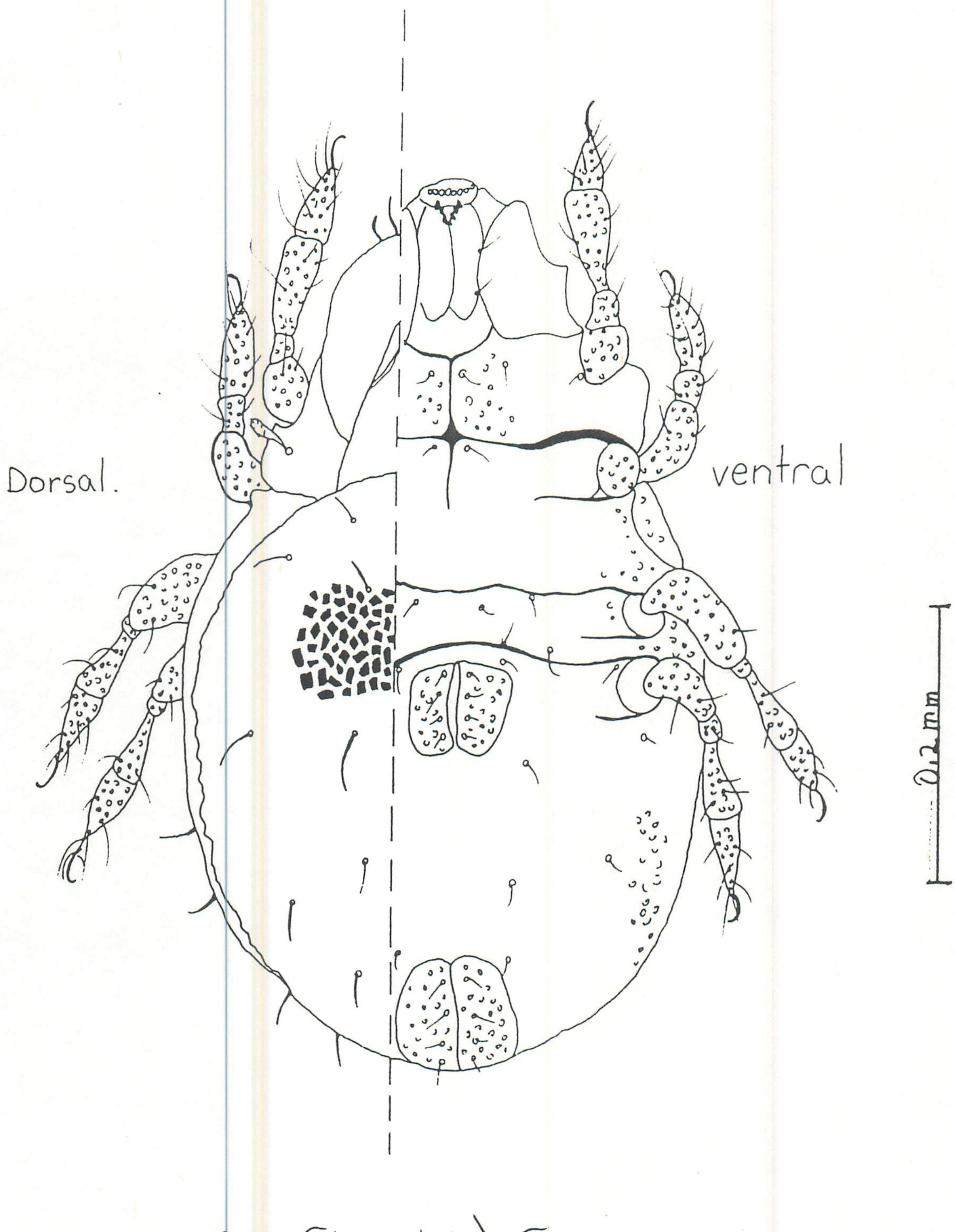
Dendrolaelaps quadrisetus

fig. 8



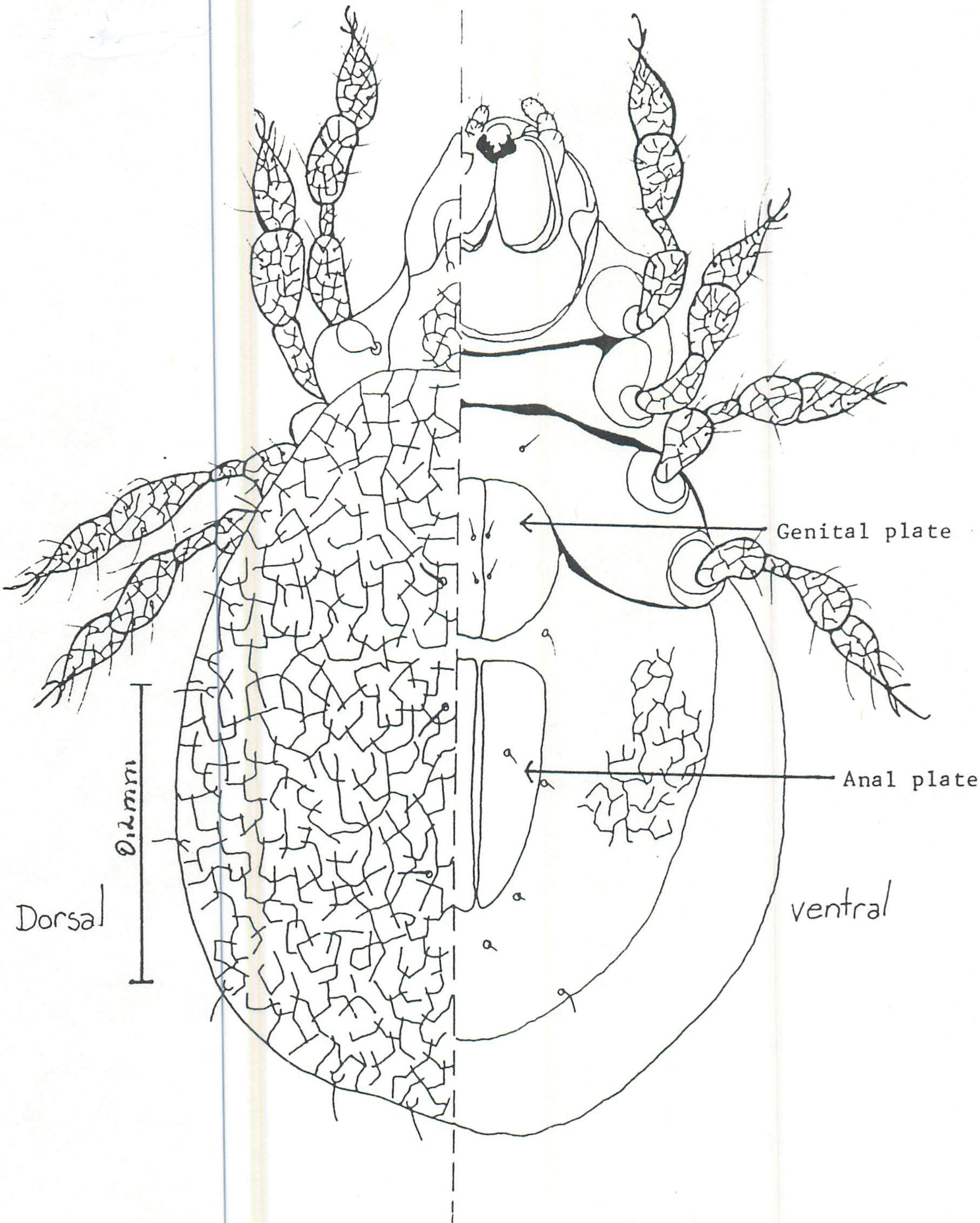
Paraxerus

fig. 9



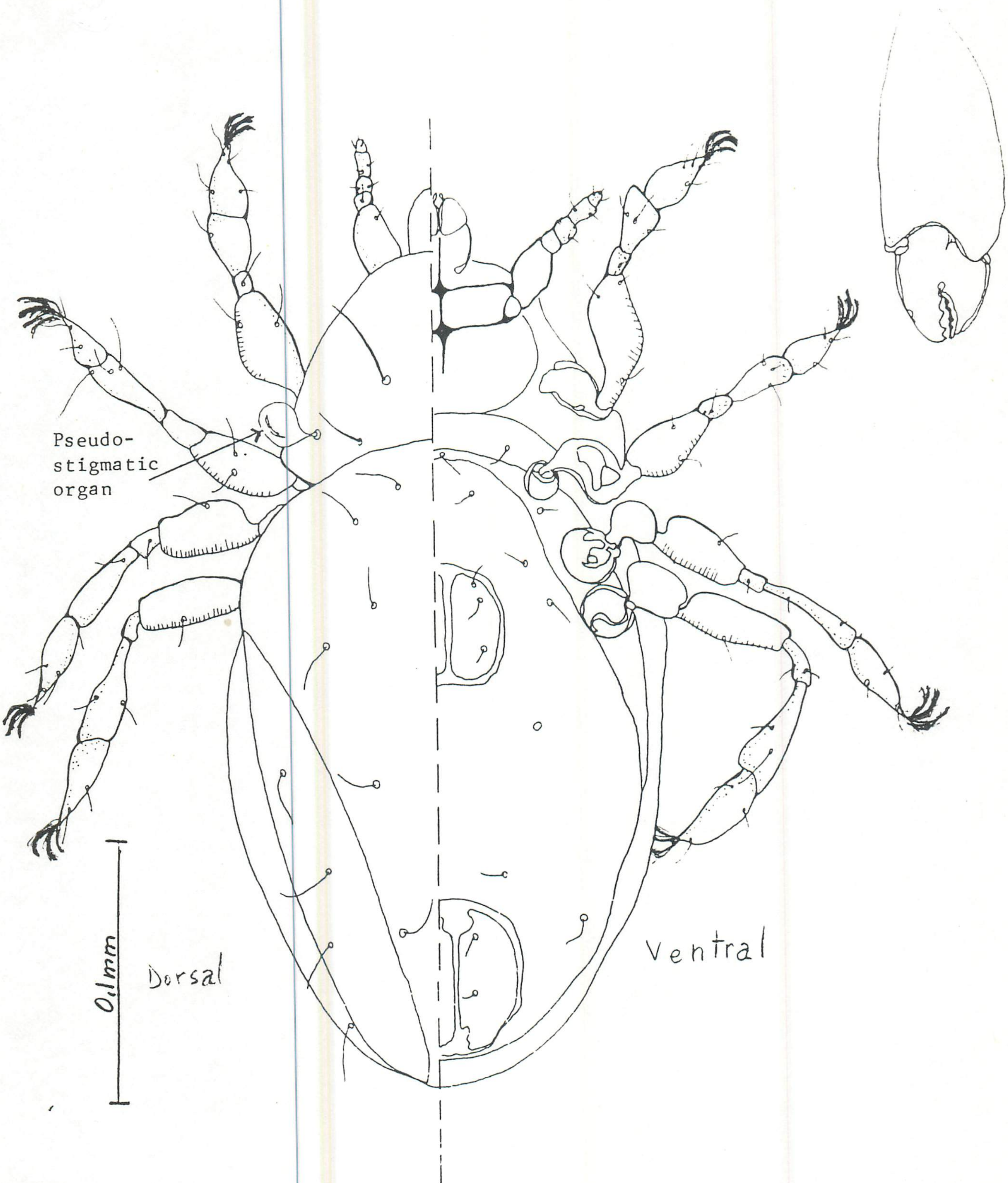
Carabodes labyrinthicus

fig. 10



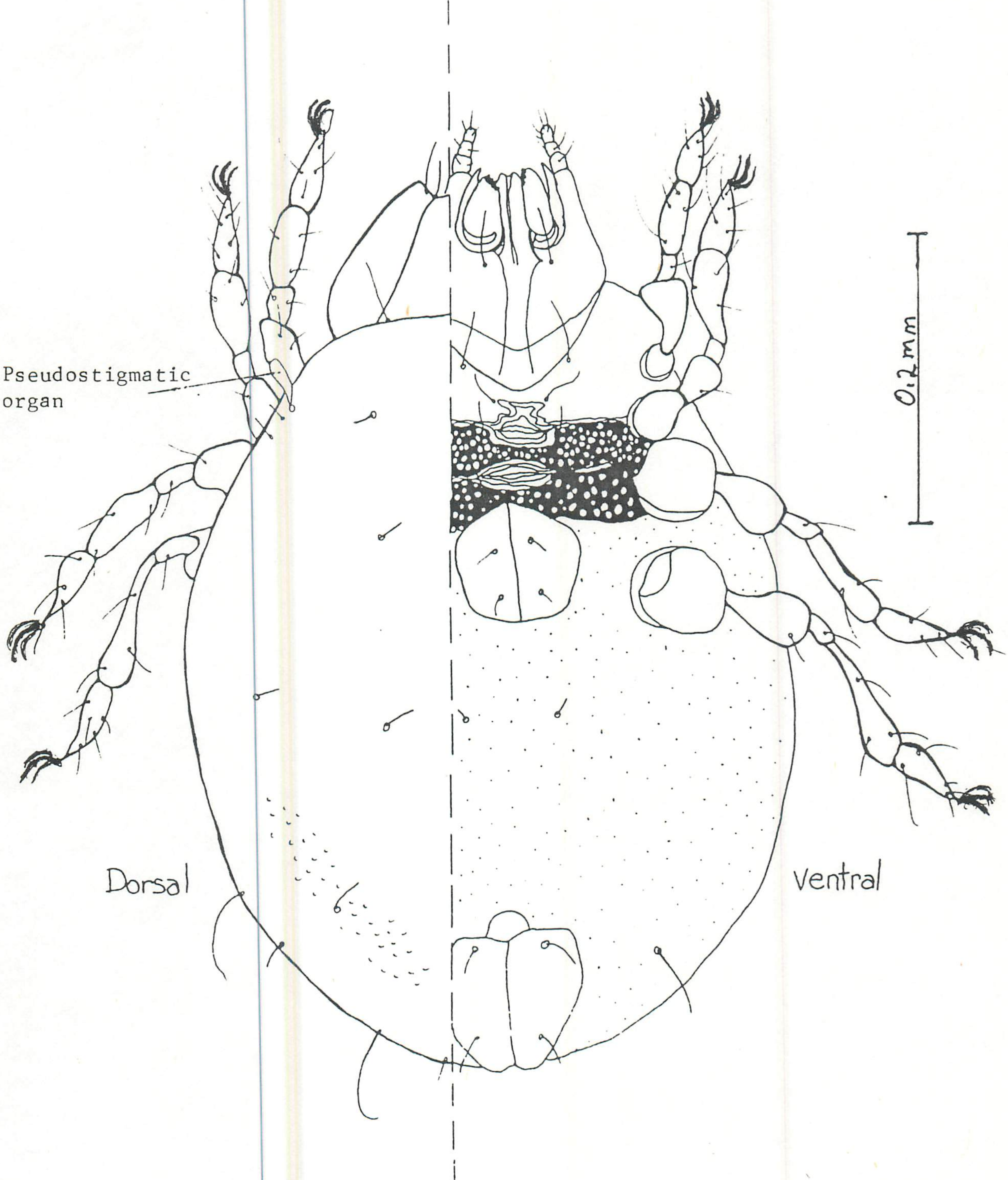
Cymbaeremaeus cymba

fig. 11



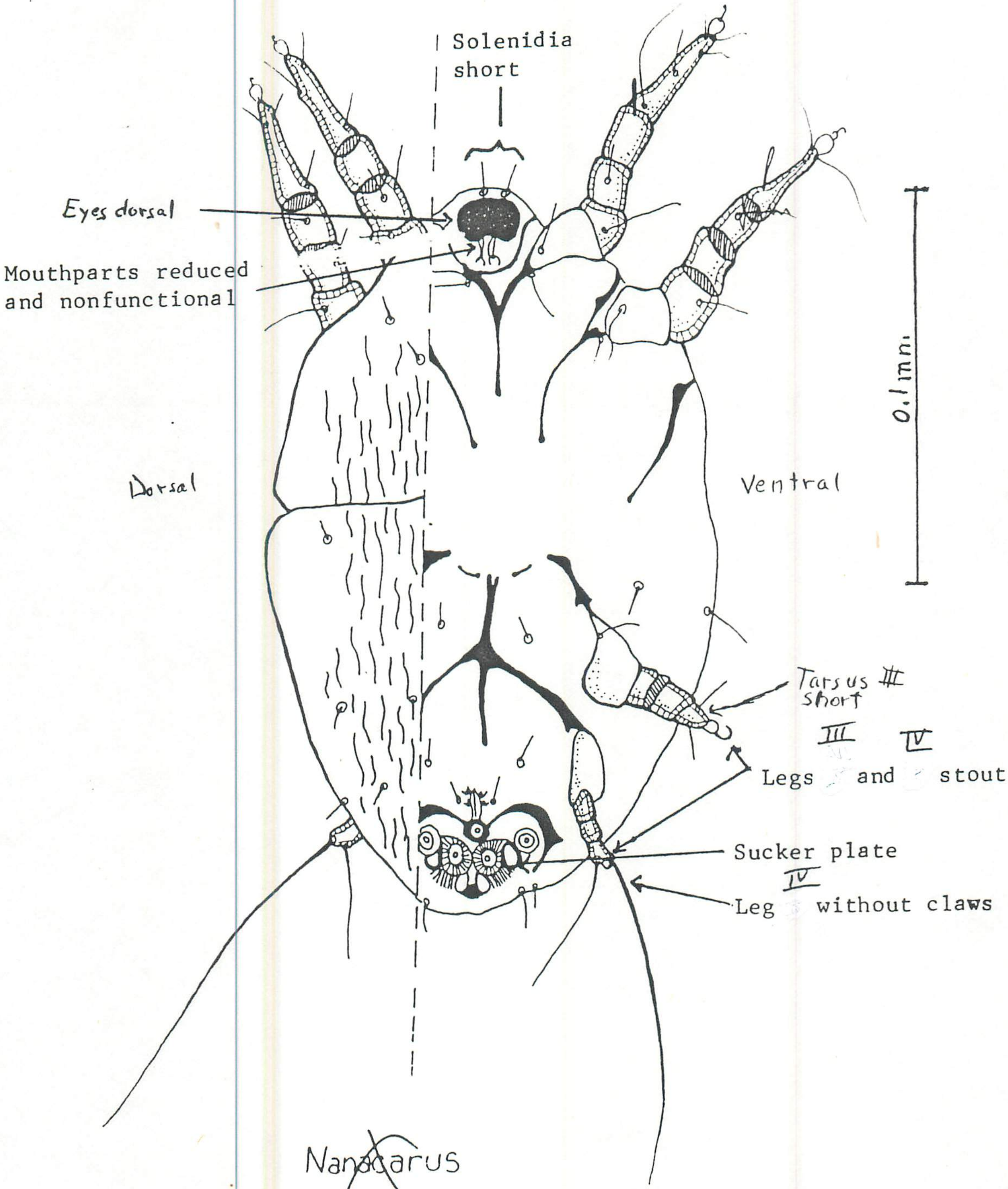
Euporibatula gessneri

fig. 12



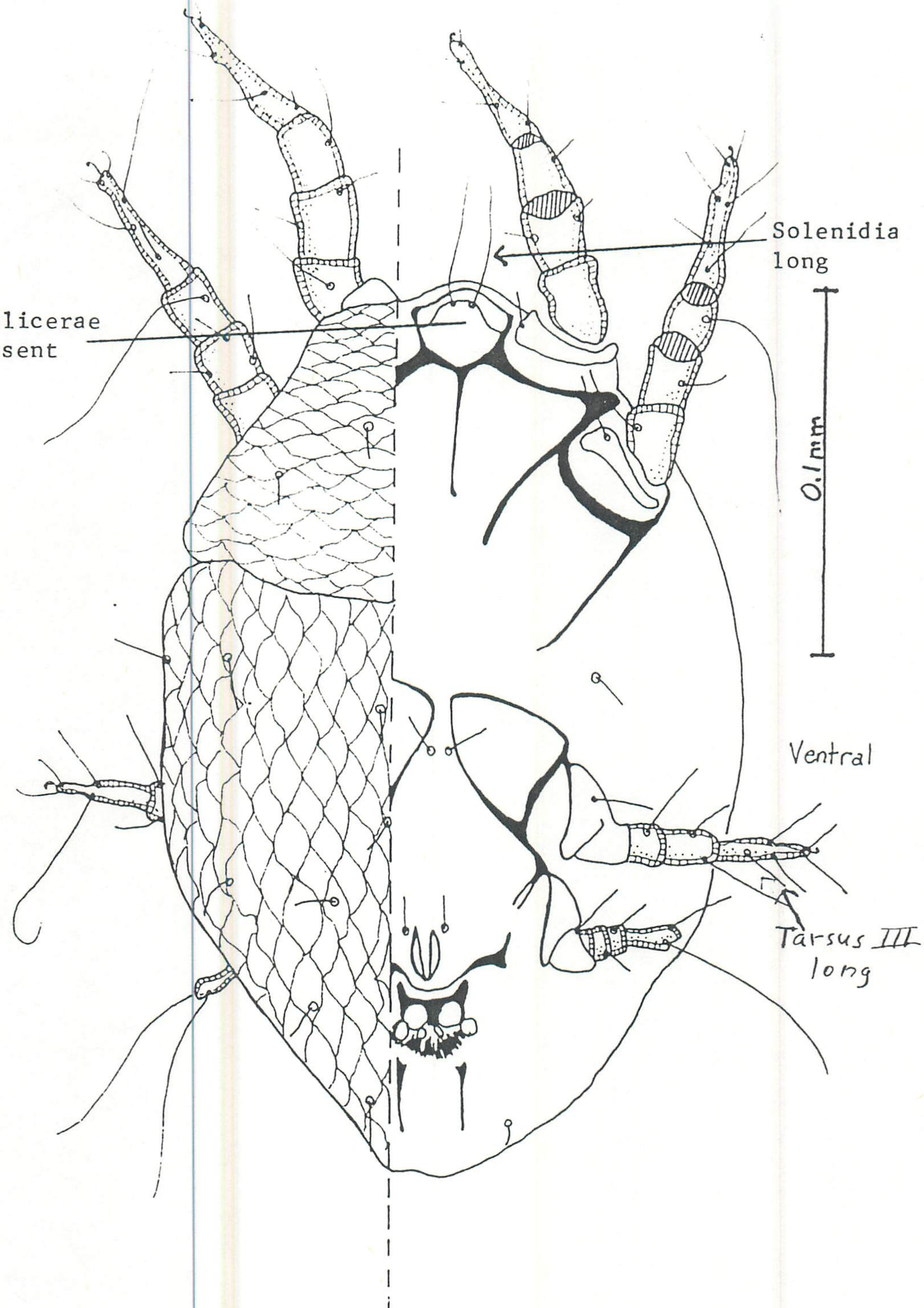
Adoristes ovatus

fig. 13



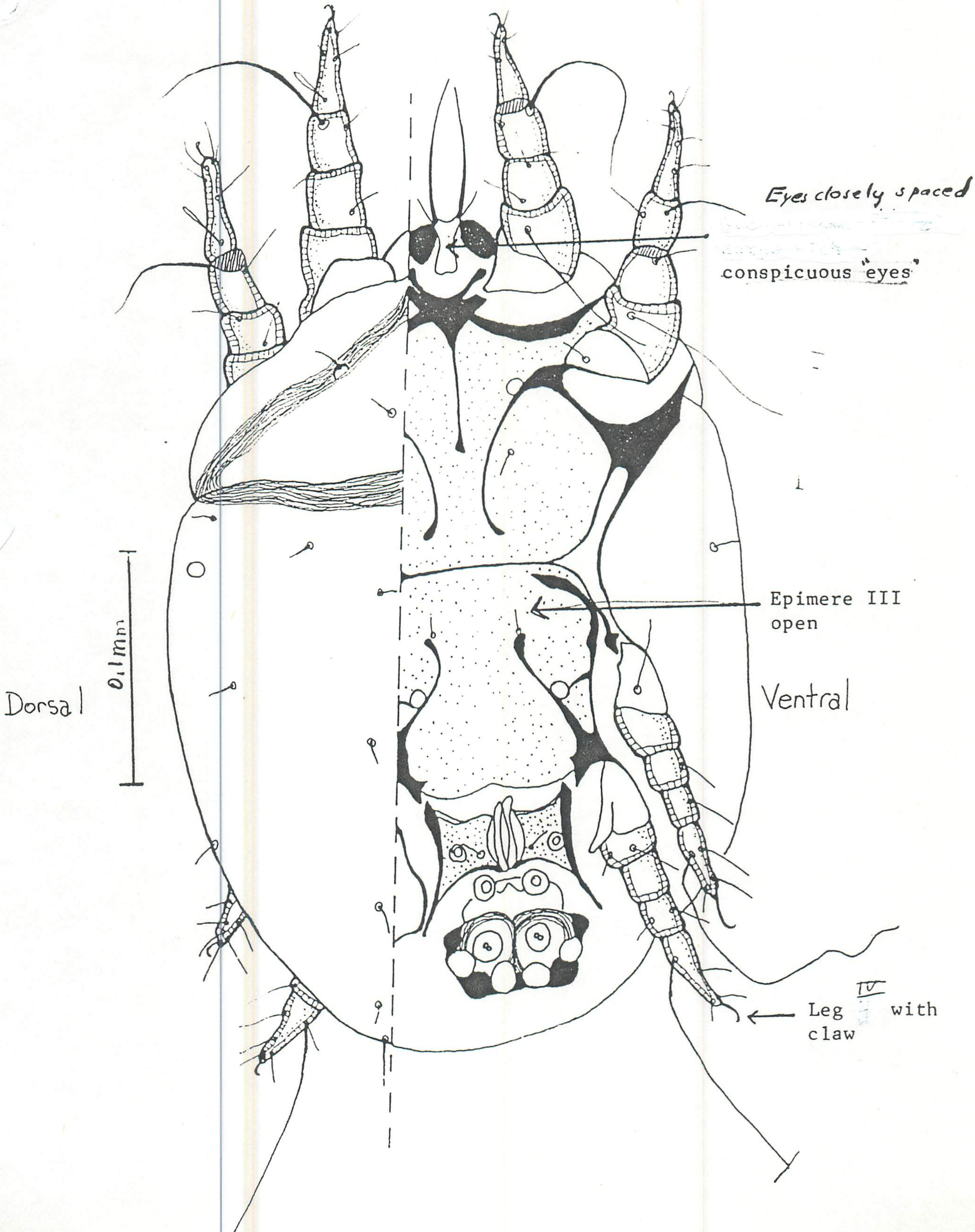
~~Nanacarus~~

fig. 14



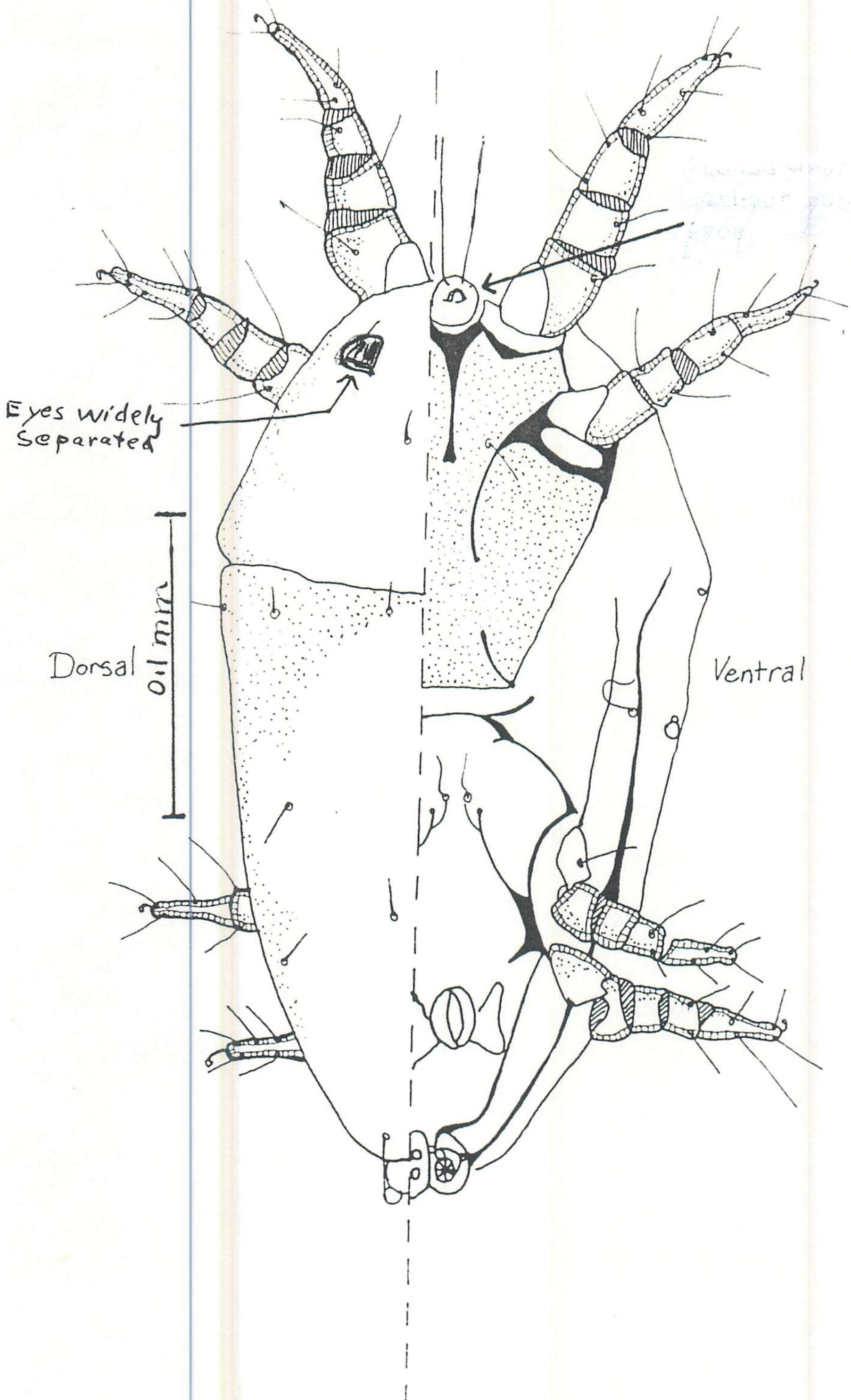
~~Calyptia~~

fig. 15



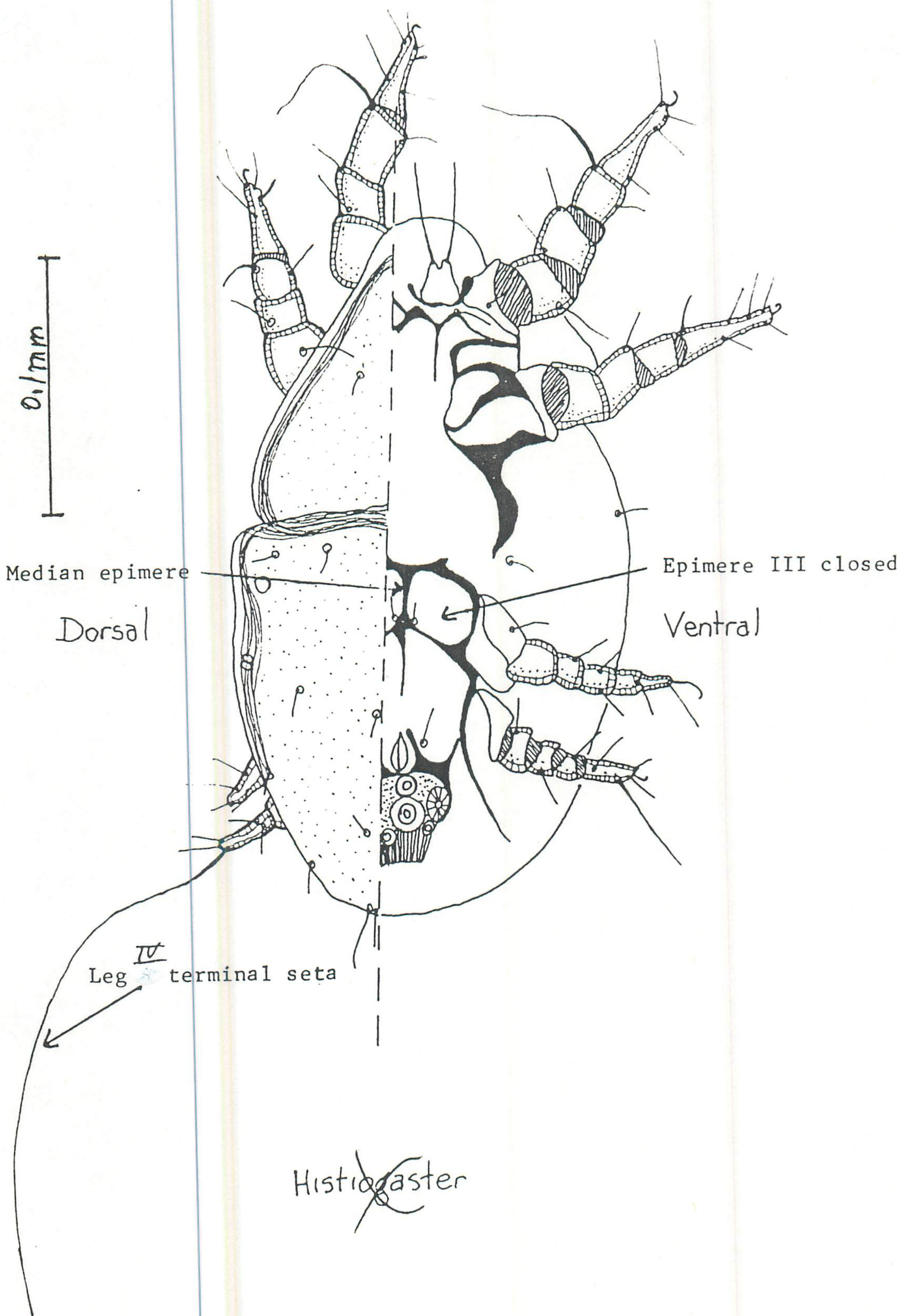
Histiogaster arborsignis

fig. 16



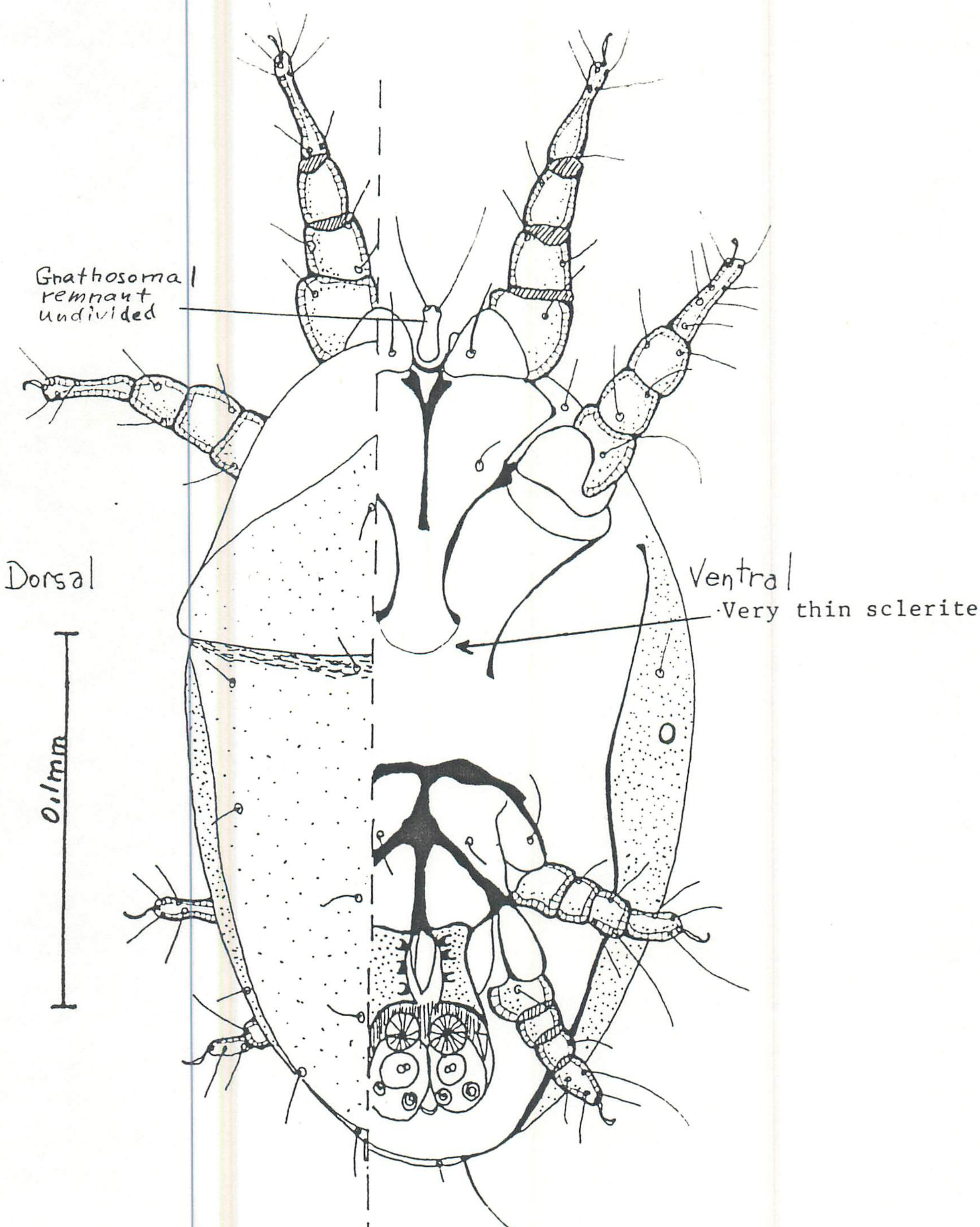
Thyreophagus cortacalis

fig. 17



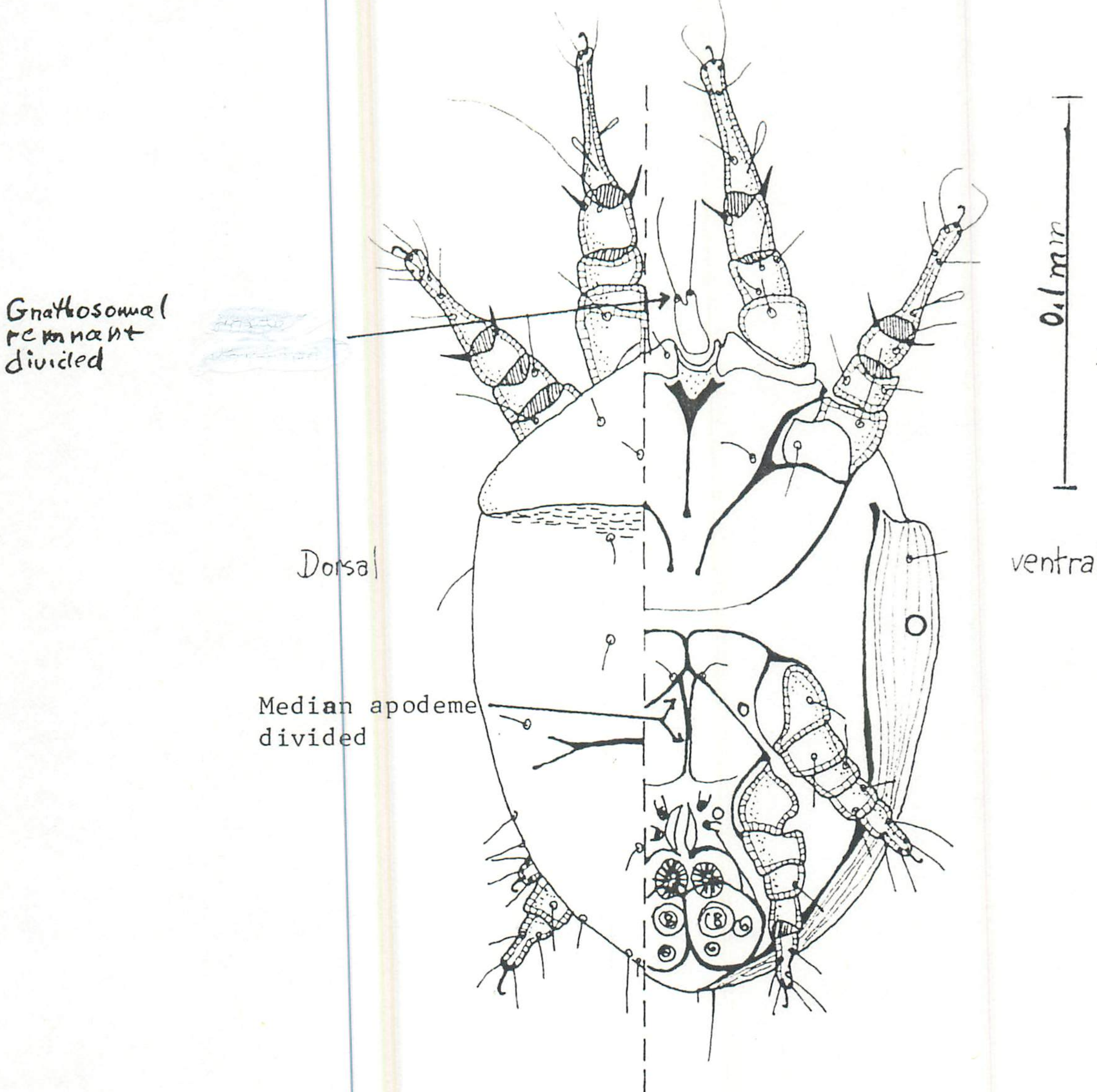
Histiogaster

fig. 18



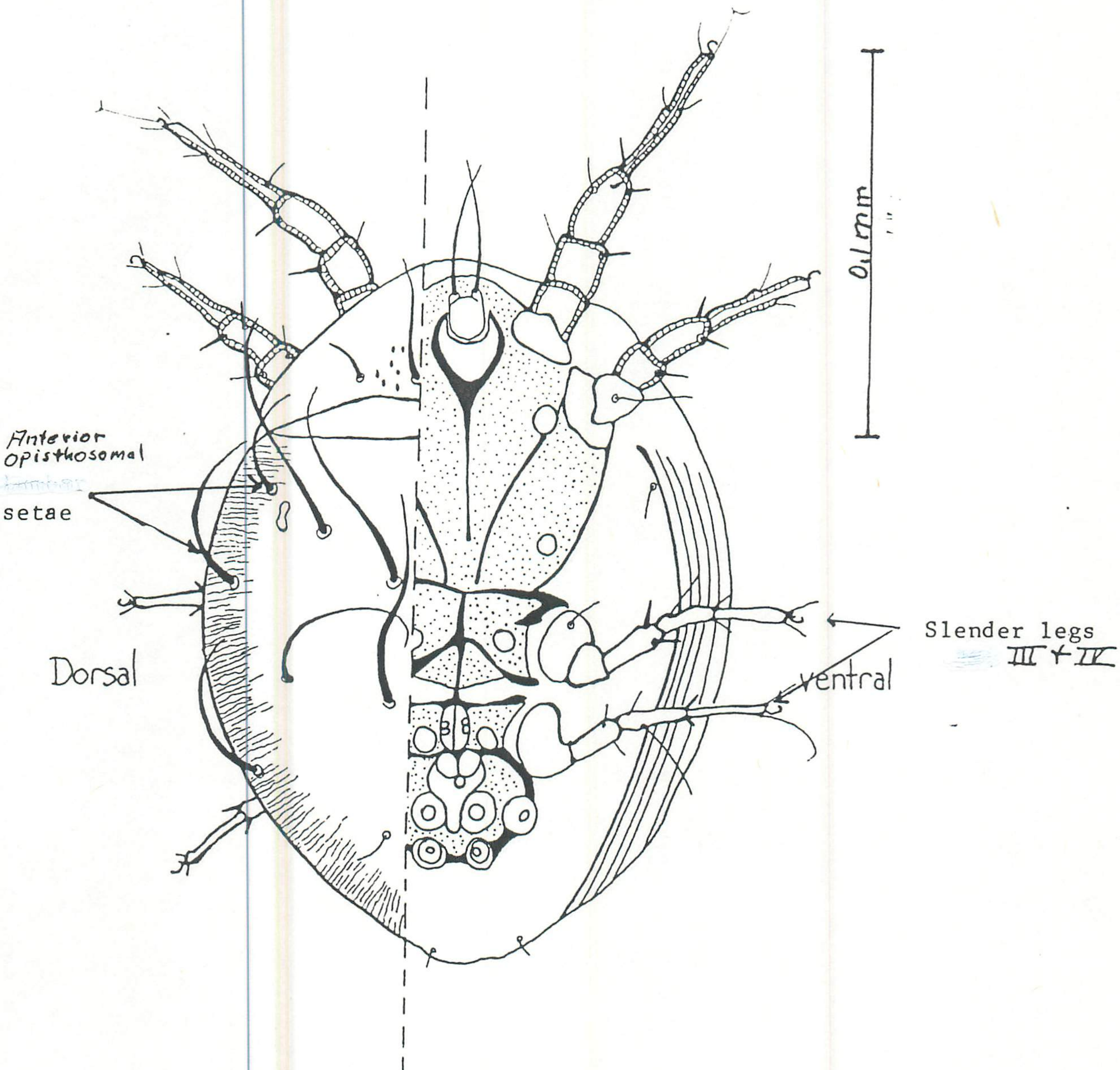
Schwiebea

fig. 19



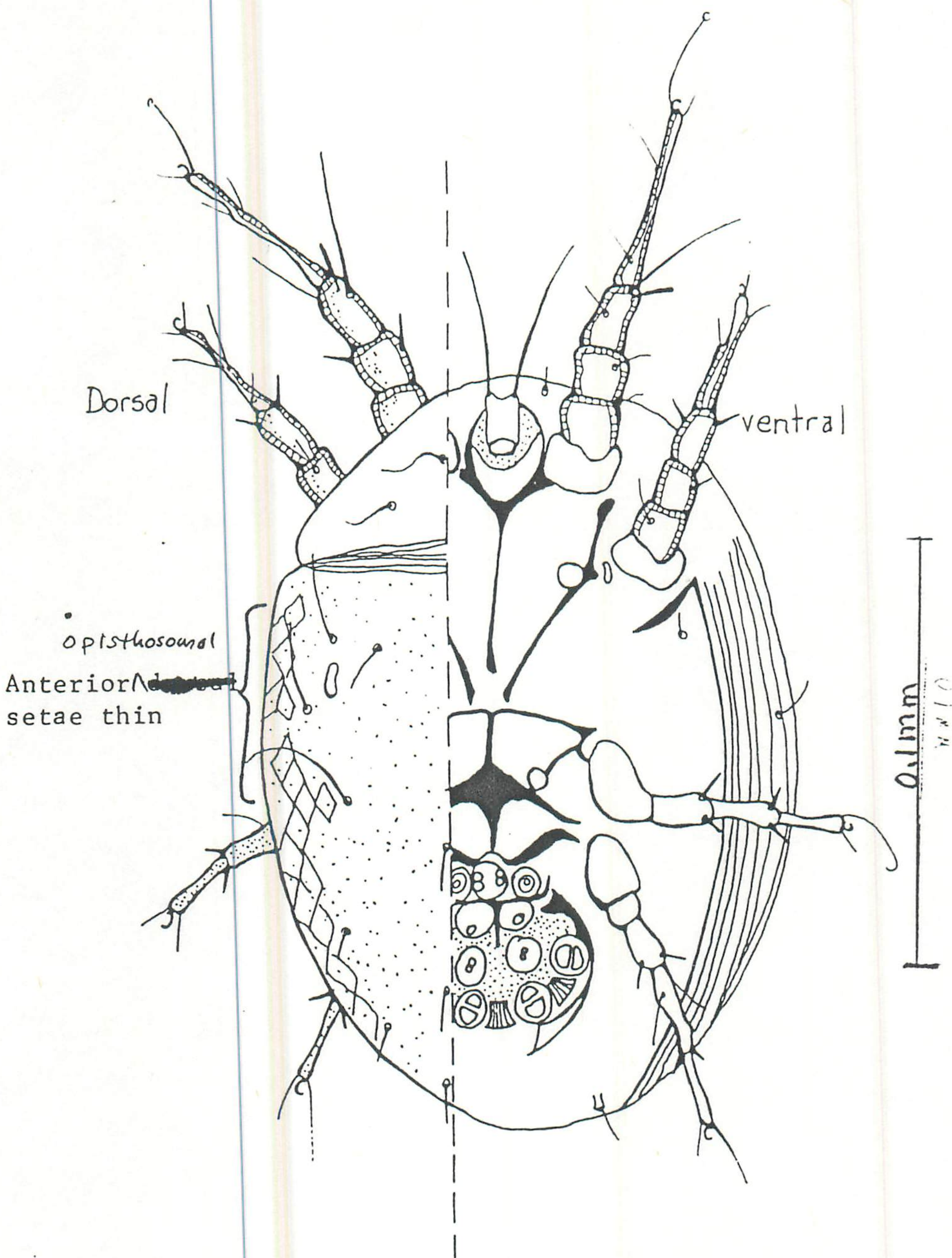
Schwiebea

fig. 20



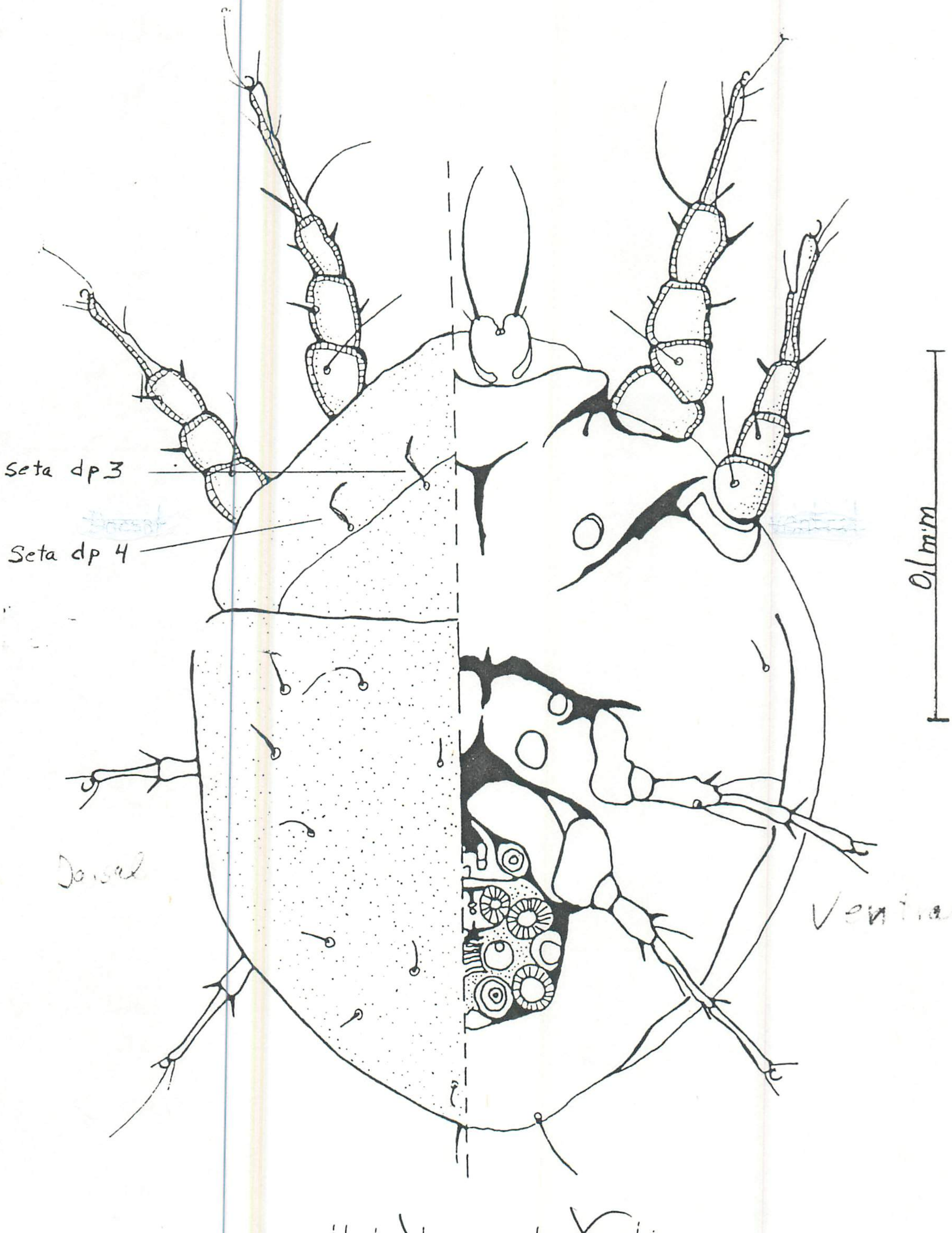
Histiostoma piceae

fig. 21



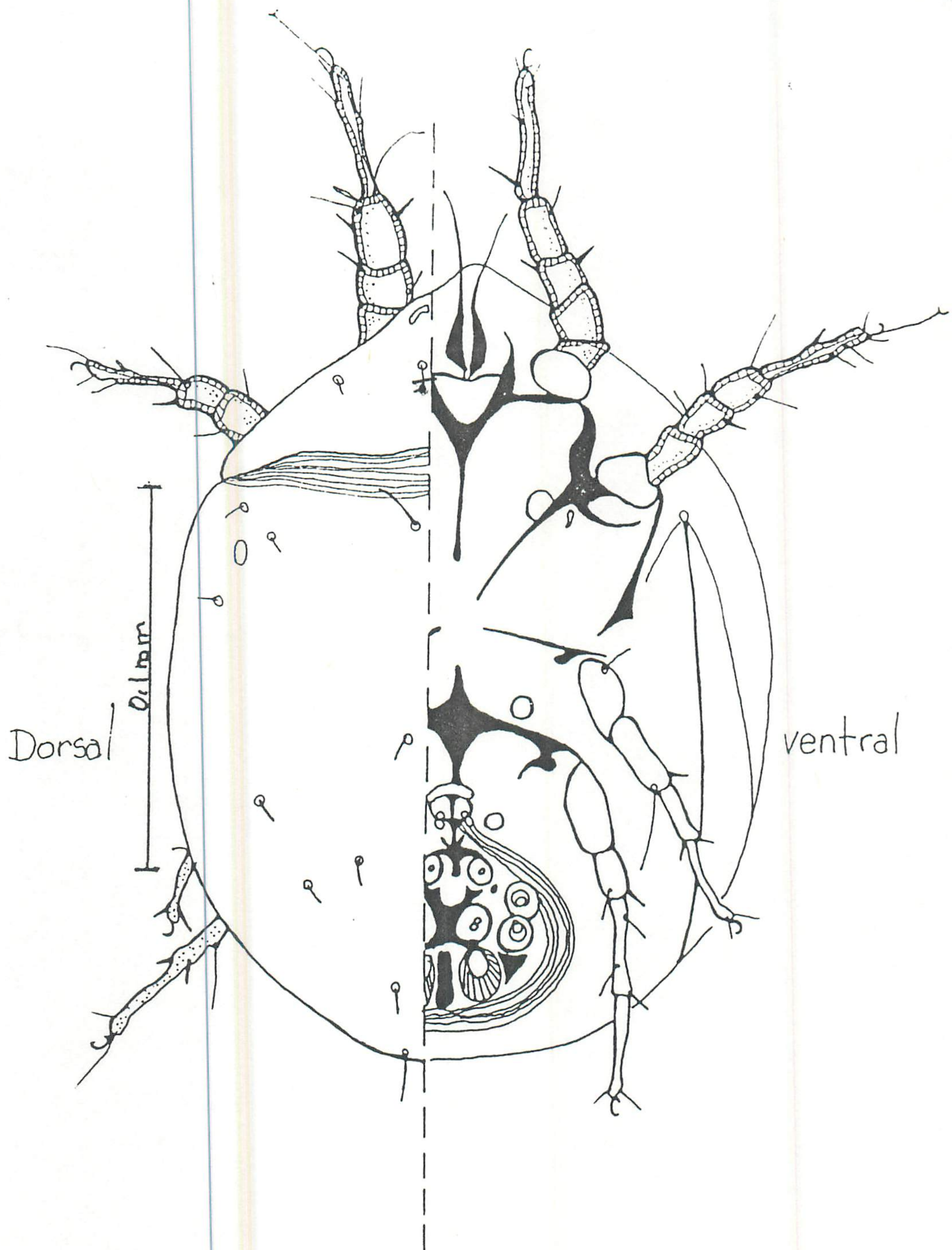
Histiostoma ~~serrata~~ n. sp. #18

fig. 22



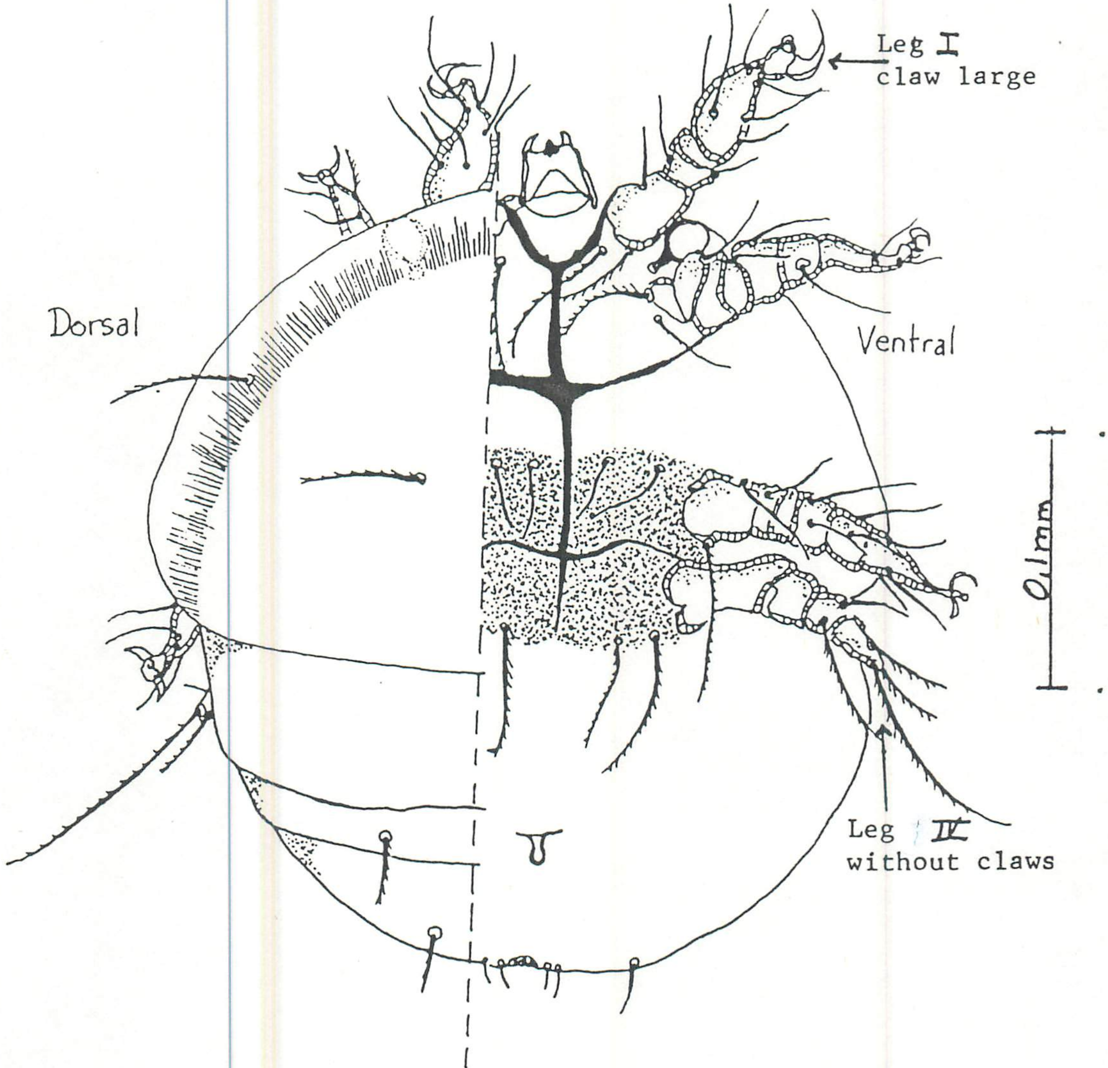
Histiostoma dryocoeti

fig. 23



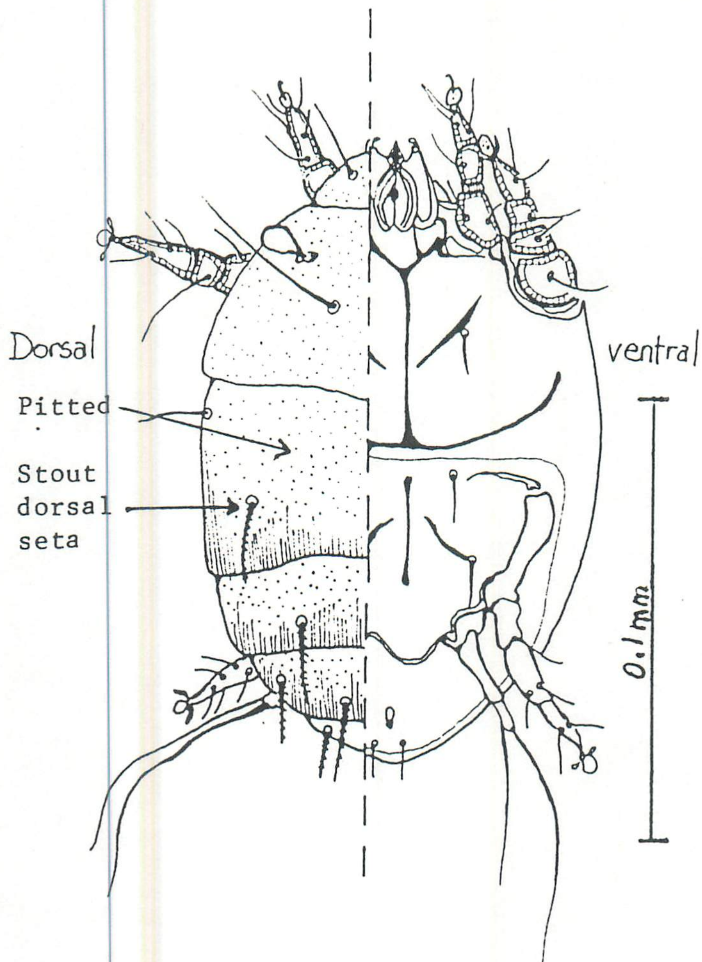
Histiostoma #25

fig. 24



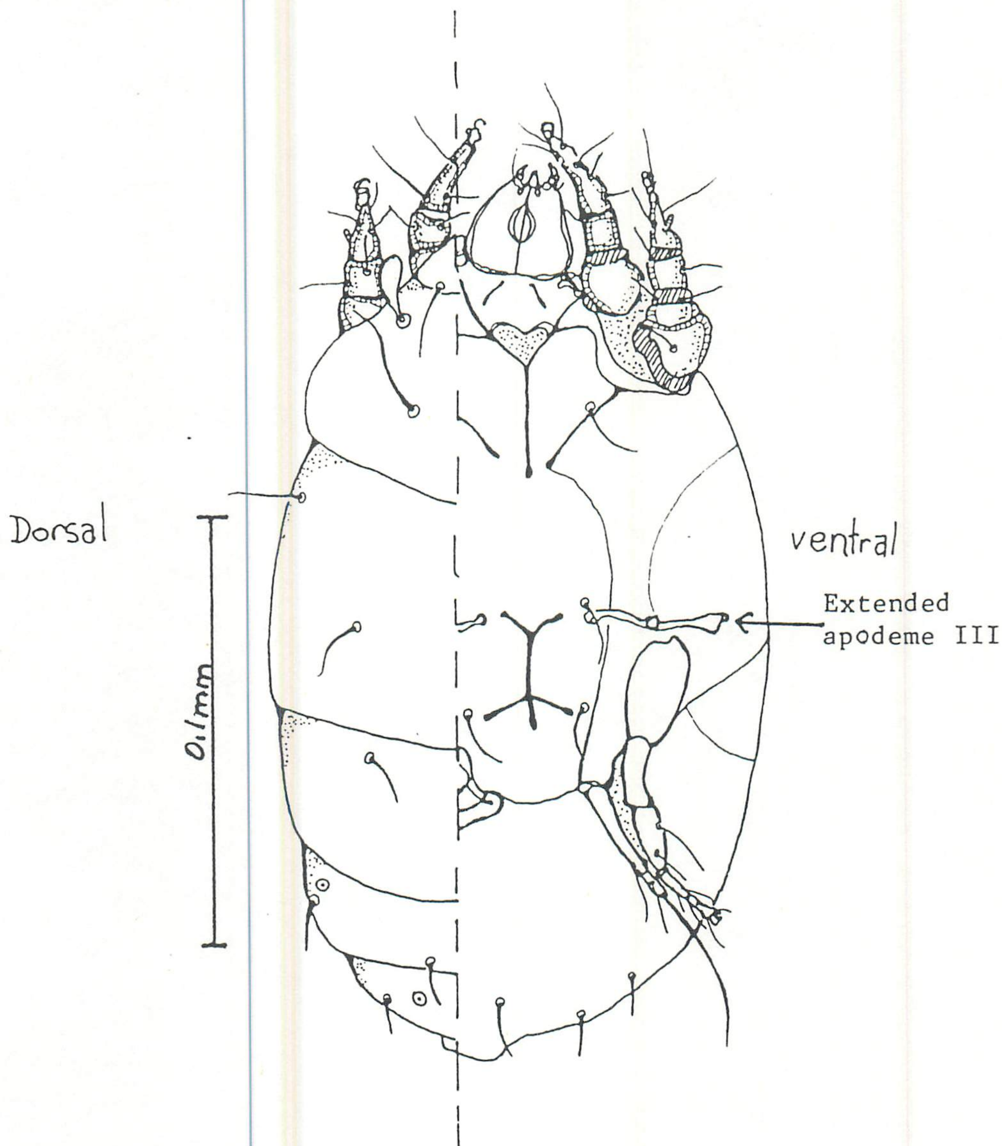
Scutacarus

fig. 25



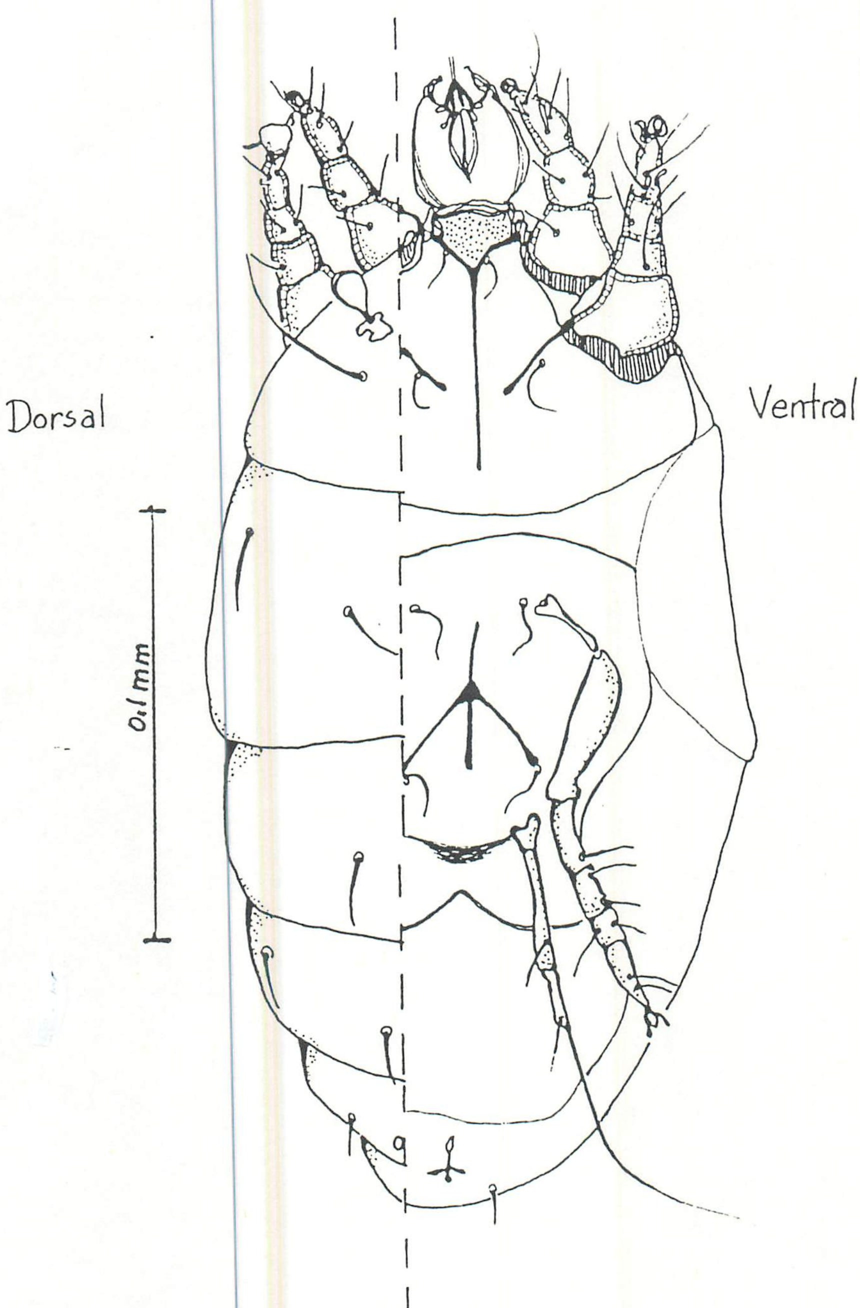
Iponemus gaebleri

fig. 26



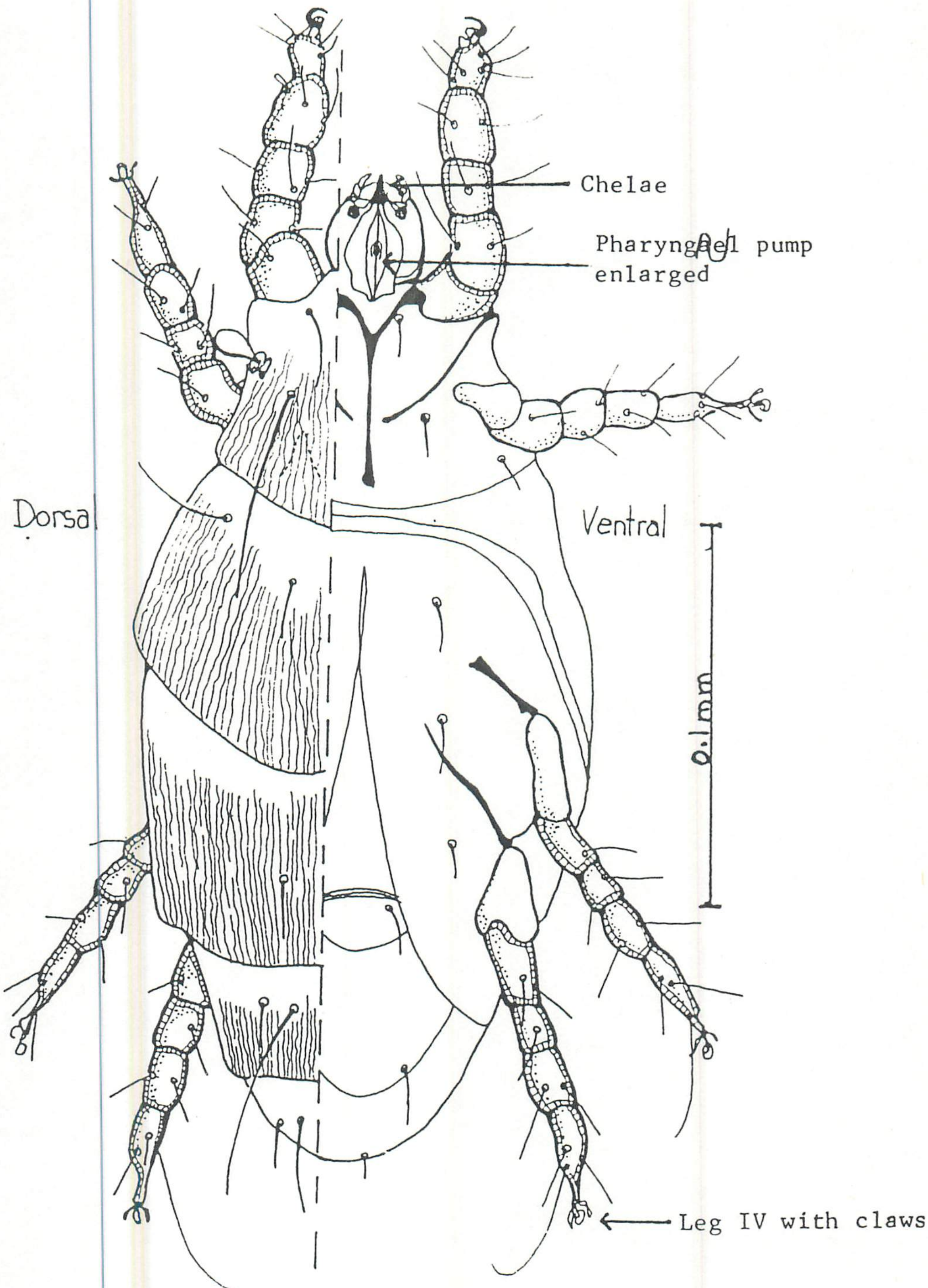
Tarsonemus subcortacalis

fig. 27



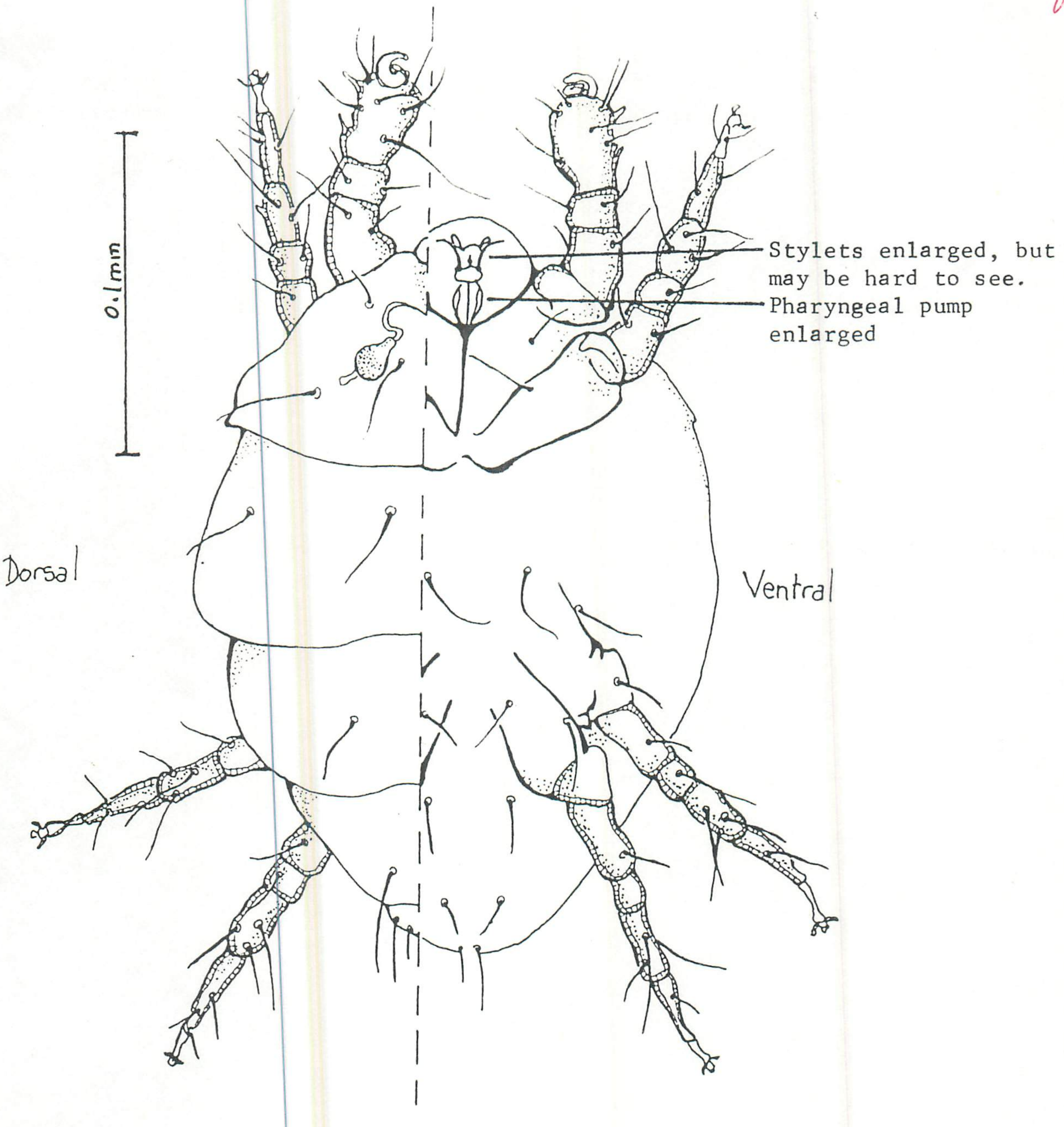
Tarsonemus Ips

fig. 28



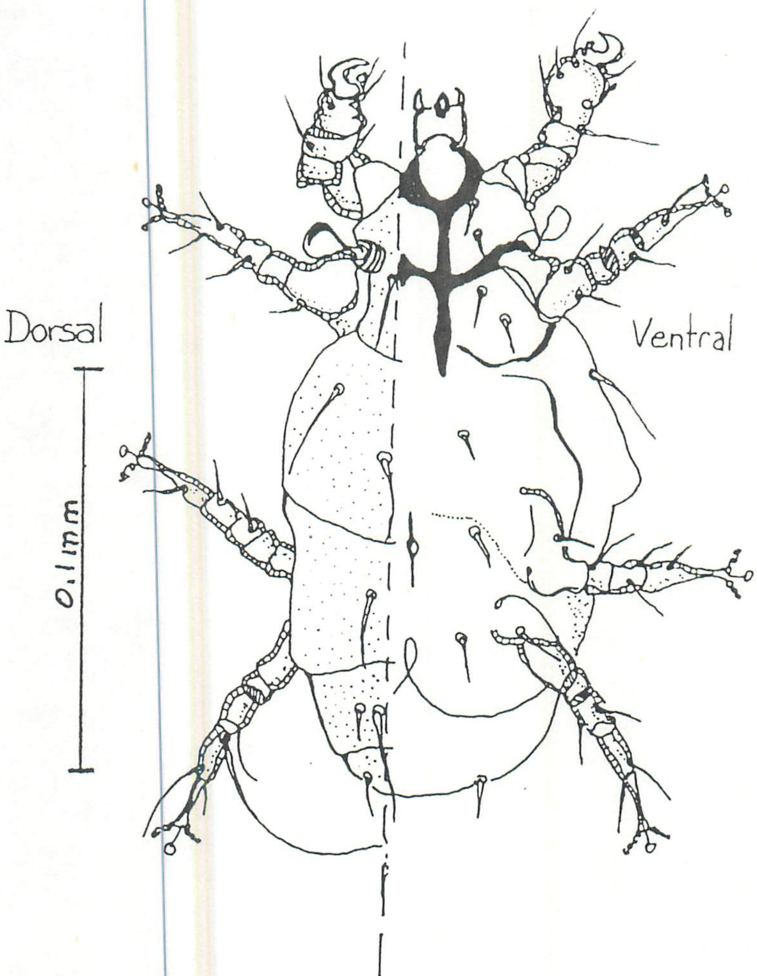
Pyemotes dryas

fig. 29

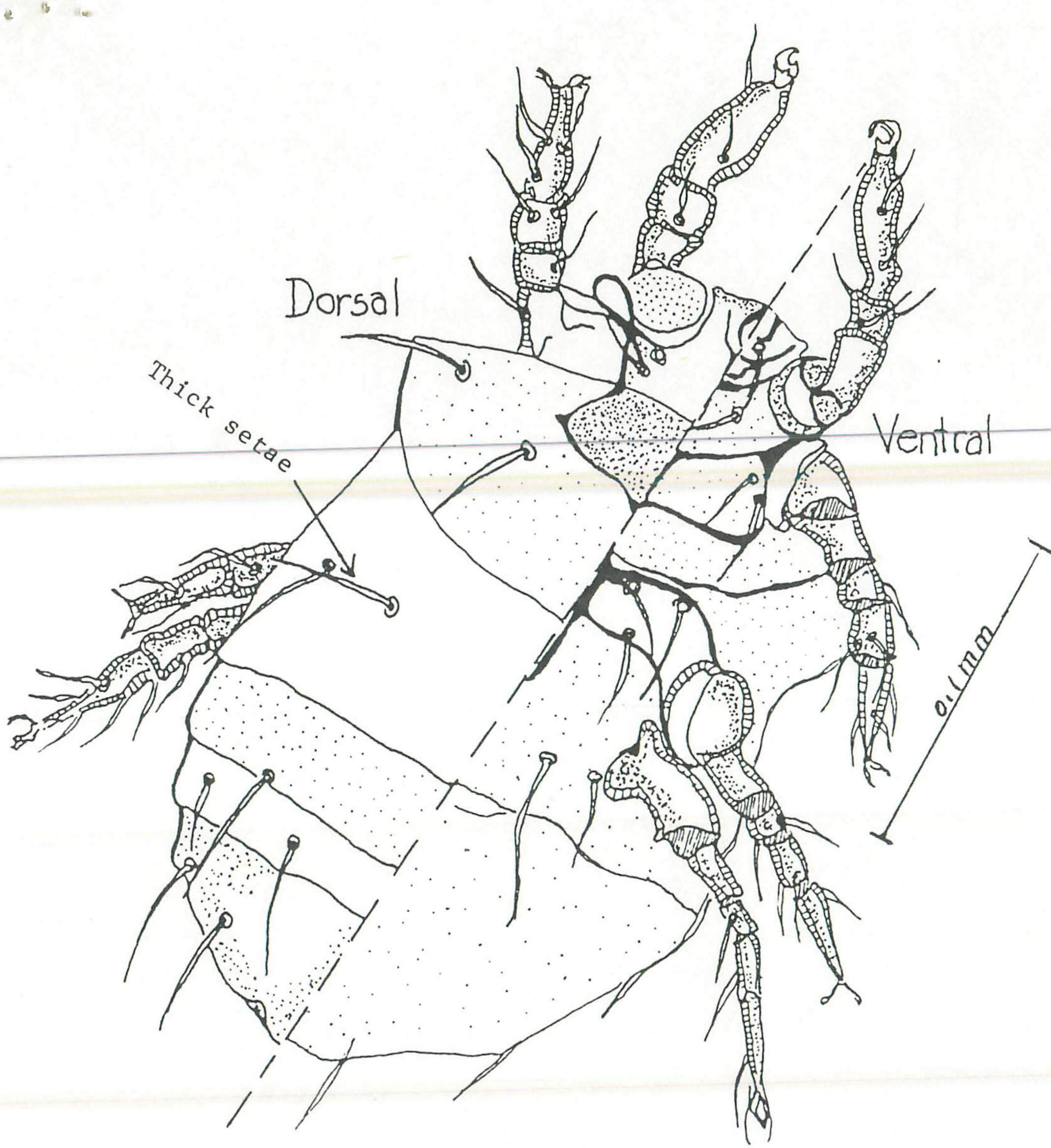


Paracarophaenax

fig. 30



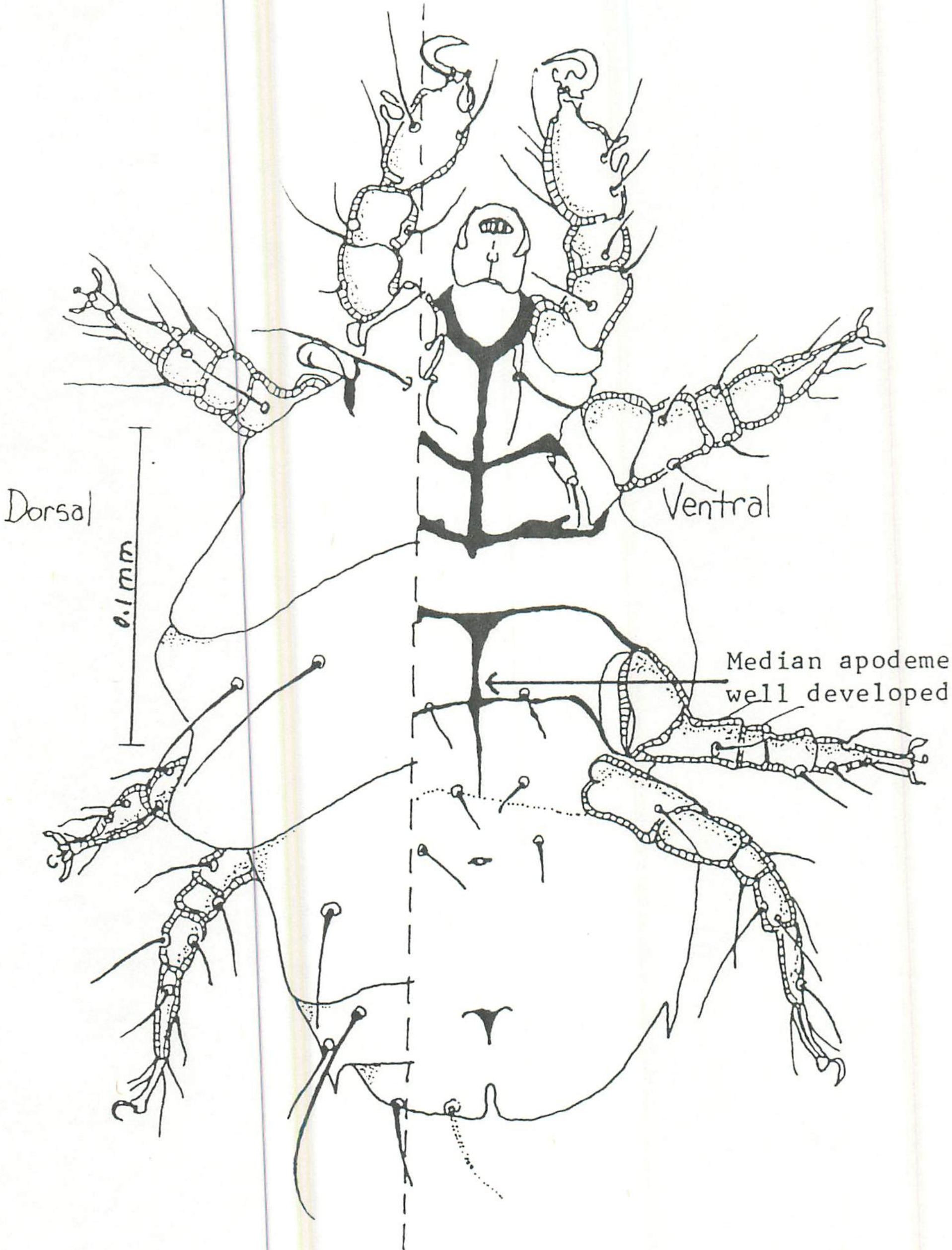
Pygmephorellus



~~Bakerdania~~

fig. 31

fig. 32



~~Bakerdania~~